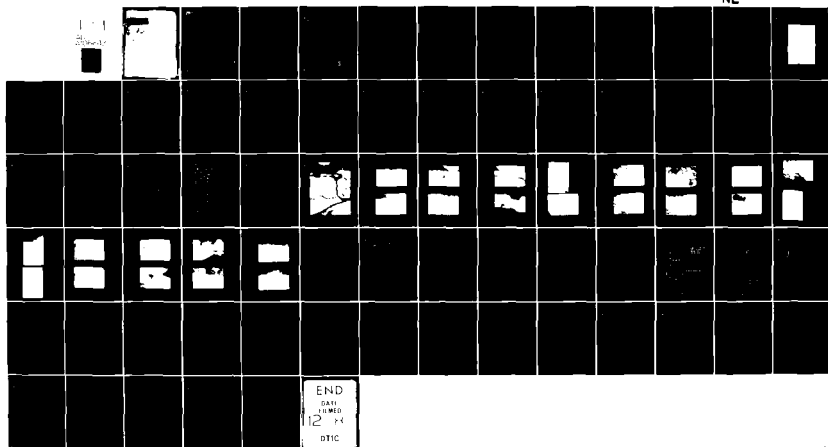


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HOSKINS-WESTERN-SONDEREGGER INC LINCOLN NE
NATIONAL DAM SAFETY PROGRAM. MCPHEETERS LAKE DAM (NO 10525), MI--ETC(U)
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18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

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REPLY TO
ATTENTION OF

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

LMSD-PD

SUBJECT: McPheeters Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the McPheeters Lake Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, emergency by the St. Louis District as a result of the application of the following criteria:

- a. The combined spillway capacity of the dam will not pass a 10-year frequency flood without overtopping of the dam. The combined spillway capacity is, therefore, considered to be unusually small and seriously inadequate.
- b. Overtopping could result in dam failure.
- c. Dam failure significantly increases the hazard to life and property downstream.

SIGNED

SUBMITTED BY:

Chief, Engineering Division

02 OCT 1980

Date

SIGNED

APPROVED BY:

Colonel, CE, District Engineer

06 OCT 1980

Date

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MCPHEETERS LAKE DAM
BUCHANAN COUNTY, MISSOURI
MISSOURI IDENTIFICATION NO. MO 10525

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
HOSKINS-WESTERN-SONDEREGGER, INC.
CONSULTING ENGINEERS
LINCOLN, NEBRASKA

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

JUNE, 1980

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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Hydrologic Computations
Principal Spillway Rating Curve
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PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
ASSESSMENT SUMMARY

Name of Dam	McPheeters Lake Dam
State Located	Missouri
County Located	Buchanan County
Stream	Tributary to Possum Hollow Creek
Date of Inspection	June 3, 1980

McPheeters Lake Dam was inspected by an interdisciplinary team of engineers from Hoskins-Western-Sonderegger, Inc. The purpose of the inspection was to make an assessment of the general conditions of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers.

McPheeters Lake Dam has a height of thirty-seven (37) feet and a storage capacity at the minimum top elevation of the dam of fifty-six (56) acre-feet. In accordance with the guidelines, a small size dam has a height greater than or equal to twenty-five (25) feet but less than forty (40) feet and a storage capacity greater than or equal to fifty (50) acre-feet but less than one thousand (1,000) acre-feet. The size classification is determined by either the storage capacity or height, whichever gives the larger size category. McPheeters Lake Dam is classified as a small size dam.

In accordance with the guidelines and based on visual observation, the dam is classified as having a high potential for damage and loss of life. Failure would threaten life and property. The estimated damage zone extends approximately two (2) miles downstream of the dam. Within the damage zone are several house trailers, at least twelve houses in the town of Agency and Highway H.

Our inspection and evaluation indicates that the spillways do not meet the criteria set forth in the recommended guidelines for a small dam having a high hazard potential. Considering the small volume of water impounded and the downstream channel from the dam, one half of the Probable Maximum Flood is the appropriate spillway design flood. The spillways will not pass the 10-year flood (10% probability flood - a flood having a ten percent chance of being exceeded in any year) without overtopping the dam. The spillways will pass 8% of the Probable Maximum Flood without overtopping the dam. The Probable Maximum Flood (PMF) is defined as the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

No design data were available for this dam. Based on the observations made during the field inspection of the dam, the following remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams:

a. Alternatives.

- (1) The spillway size and/or the height of dam should be increased to pass 50 percent of the probable maximum flood without overtopping the dam.


b. Operation and Maintenance Procedures.

- (1) Additional studies should be made to determine the present maximum capacity of the reservoir and the damages that would result from failure of this dam.
- (2) Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" should be performed and made a matter of record.
- (3) The causes (s) of slumping over the principal spillway pipe should be determined and remedial measures taken to correct the problem.
- (4) Stabilizing and/or controlling the head cut and gully at the exit of the emergency spillway is not practical for this project (This would probably require a concrete drop or chute; another dam downstream; etc.). It is recommended, however, that the headward progress of the gully be regularly monitored and that these records be made a part of this project file.


Diverting the runoff from the farmland adjoining the spillway on the left (north) side would aid in reducing the headward progress of the gully.

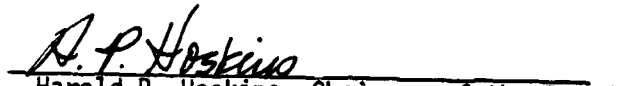
- (5) The inlet to the principal spillway should be cleared and measures taken to prevent logs and trash from blocking the spillway.

- (6) The main channel of the emergency spillway should be vegetated.
- (7) Regular mowing of the embankment slopes should be continued.


Key S. Decker
E-3703


Gordon Jamison


Garold Ulmer
E-19246


Harold P. Hoskins, Chairman of the Board
Hoskins-Western-Sonderegger, Inc.
E-8696

FORM 1

BINDING EDGE

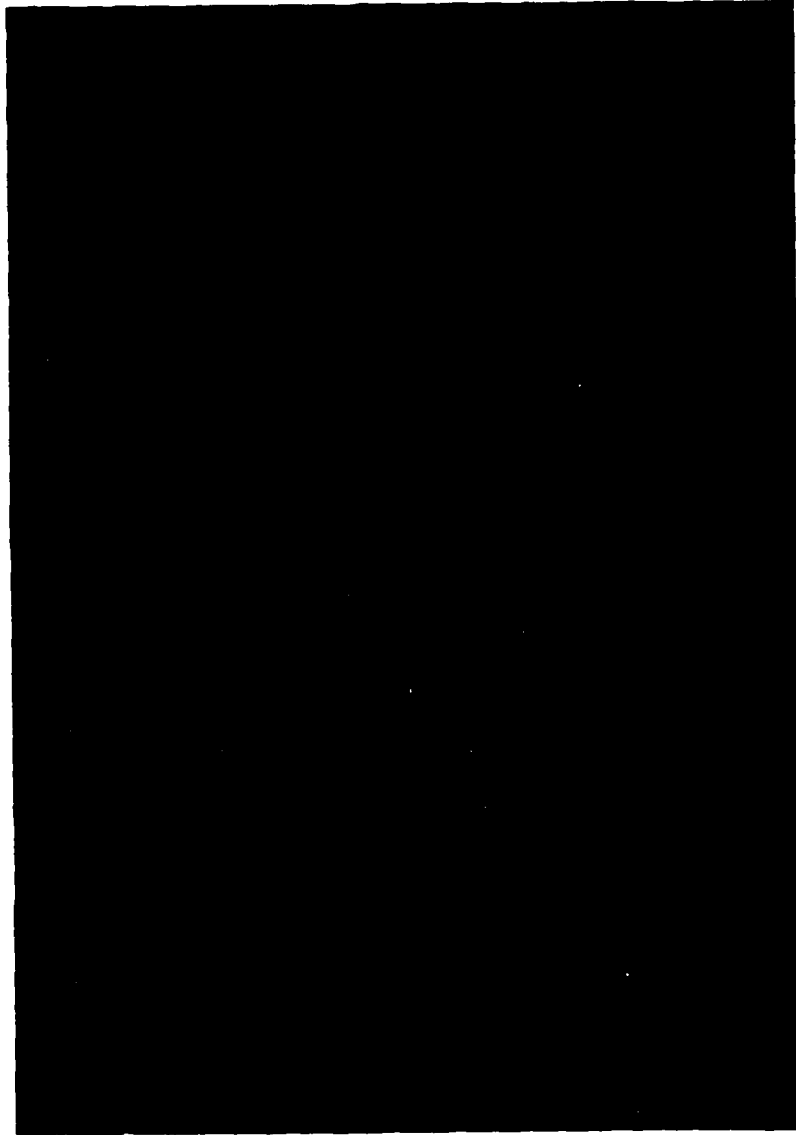


PHOTO NO. 1 - OVERVIEW

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
MCPHEETERS LAKE DAM - MO 10525
BUCHANAN COUNTY, MISSOURI

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

- a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of McPheeters Lake Dam be made.
- b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.
- c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams, "Appendix D to "Report of the Chief of Engineers on the National Program of Inspection of Dams," dated May, 1975, and published by the Department of the Army, Office of the Chief of Engineers.

1.2 DESCRIPTION OF PROJECT

- a. Description of Dam and Appurtenances.
 - (1) The dam is an earth fill approximately 350 feet in length and 37 feet high, constructed in a deeply incised gully cut through loess that is typical of the rolling hill uplands adjacent to the Missouri River. The maximum water storage at the minimum top elevation of the dam is 56 acre-feet.
 - (2) The principal spillway is uncontrolled and consists of a 48-inch diameter corrugated metal pipe drop inlet (riser) which is connected to a 36-inch diameter corrugated metal pipe conduit that passes through the dam.
 - (3) An uncontrolled, vegetated earth emergency spillway is cut through the left abutment.
- b. Location. The dam is located in the central part of Buchanan County, Missouri about 1 mile west of the town of Agency. It is located in the NW 1/4, Sec. 30, T56N, R34W.

- c. Size Classification. McPheeters Lake Dam has a height of 37 feet and a storage capacity of 56 acre-feet. This dam is classified as a small size dam. A small size dam has a height greater than or equal to 25 feet but less than 40 feet and a storage capacity greater than or equal to 50 acre-feet but less than 1,000 acre-feet. The size classification is determined by either the storage or height, whichever gives the larger size category.
- d. Hazard Classification. Guidelines for determining hazard classification are presented in the same guidelines as referenced in paragraph 1.1c above. Based on referenced guidelines and visual observation McPheeters Lake Dam is in the High Hazard Classification. The estimated damage zone extends approximately two miles downstream of the dam. Within the damage zone are several house trailers, at least twelve houses in the town of Agency and Highway H.
- e. Ownership. The dam is owned by Mr. and Mrs. Robert A. McPheeters, Rt. #1, Box 80A, Agency, Missouri 64401.
- f. Purpose of Dam. The dam was constructed primarily for erosion and gully control. It does provide flood protection.
- g. Design and Construction History. Some technical assistance in laying out the dam and some cost sharing were provided by the A.S.C.S. office in St. Joseph, Missouri. However, no plans or design notes were available from that office.

The dam was constructed in 1969 by John Dodge of St. Joseph.

- h. Normal Operating Procedure. There are no operating facilities for this dam. The pool level is controlled by rainfall, infiltration, evaporation, and the capacity of the uncontrolled spillways.

1.3 PERTINENT DATA

- a. Drainage Area. 616.5 acres (0.963 square miles).
- b. Discharge at Damsite.
 - (1) All discharges at the damsite are through an uncontrolled 48-inch diameter corrugated metal pipe drop inlet (riser) which is connected to a 36-inch diameter corrugated metal pipe conduit and through an uncontrolled, vegetated earth emergency spillway.
 - (2) Estimated maximum flood at damsite -- Mr. McPheeter stated that water had run in the field and over the trail on the right side of the dam in about 1972 or 1973.
 - (3) The principal spillway capacity varies from 0 c.f.s. at elevation 890.0 feet to 105 c.f.s. at the crest of the emergency spillway (elevation 892.9 feet) to 128 c.f.s. at the minimum top of dam (elevation 894.7 feet).

(4) The emergency spillway capacity varies from 0 c.f.s. at its crest (elevation 892.9 feet) to 270 c.f.s. at minimum top of dam (elevation 894.7 feet).

(5) Total spillway capacity at the minimum top of dam is 400 c.f.s. \pm .

c. Elevations (feet above M.S.L.).

(1) Observed pool - 890.0

(2) Normal pool - 890.0

(3) Spillway crest (s)

Principal - 890.0

Emergency - 892.9

(4) Maximum experienced pool - 895 \pm

(5) Top of dam (minimum) - 894.7

d. Reservoir. Length (feet) of pool -

(1) At principal spillway crest - 1200 \pm

(2) At emergency spillway crest - 1900 \pm

- (3) At top of dam (minimum) - 2500 \pm

e. Storage (Acre-feet).

(1) Observed pool - 28 \pm

(2) Normal pool - 28 \pm

(3) Spillway crest (s).

Principal - 28 \pm

Emergency - 40 \pm

(4) Maximum experienced pool - 56 \pm

(5) Top of dam (minimum) - 56 \pm

f. Reservoir Surface (Acres).

(1) Observed pool - 3 \pm

(2) Normal pool - 3 \pm

(3) Spillway crest (s).

Principal - 3 \pm

Emergency - 6 \pm

(4) Maximum experienced pool - 10 \pm

(5) Top of dam (minimum) - 10 \pm

g. Dam.

(1) Type - Homogeneous earth fill

(2) Length - 350 ft. \pm

(3) Height - 37 ft. \pm

(4) Top width - 16 ft. \pm

(5) Side slopes.

(a) Downstream 1V on 2.8 H (measured)

(b) Upstream 1V on 4.4 H (measured)

(6) Zoning - None

(7) Impervious core - None

(8) Cutoff - Mr. McPheeters reported that the cutoff extended into shale across the bottom and part way up the abutments.

(9) Grout curtain - None

(10) Wave protection - None

(11) Drains - None

h. Diversion Channel and Regulating Tunnel. None

i. Spillway.

(1) Principal

(a) Type - Uncontrolled, 48-inch diameter corrugated metal pipe drop inlet (riser) connected to a 36-inch diameter corrugated metal pipe conduit passing through the embankment.

(b) Crest (invert) elevation -890

Outlet - 862.9

(c) Length - 157 ft. \pm

(2) Emergency

- (a) Type - vegetated earth, uncontrolled, cut through the left abutment and having a parabolic cross section. There is also a low area extending about 130 feet on the right end of the dam that serves as an emergency spillway.
- (b) Control section - A near level section extending about 100 ft. downstream from the centerline of the dam.
- (c) Crest elevation - 892.9
- (d) Upstream Channel - open, 8% \pm grade from centerline of dam to reservoir.
- (e) Downstream Channel - The spillway drops vertically over the edge of the old gully bank about 150 ft. downstream from the centerline of the dam.

j. Regulating Outlets. None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design data were available for this dam.

2.2 CONSTRUCTION

No construction data were available. It was reported by Mr. McPheeter that the dam was constructed in 1969 by Mr. Dodge of St. Joseph, Missouri.

2.3 OPERATION

No data were available on spillway operation. It was reported by Mr. McPheeter that a 6-inch rain in 1972 or 1973 produced a 3 to 4 foot depth of flow through the emergency spillway and 1 to 2 foot depth of flow around the right end of the dam.

2.4 EVALUATION

- a. Availability. No data were available.
- b. Adequacy. Design data were not available for this dam. The field surveys and visual observation presented herein are considered adequate to support the conclusions of this report. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.
- c. Validity. Not applicable.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the McPheeters Lake Dam was made on June 3, 1980. Engineers from Hoskins-Western-Sonderegger, Inc., Lincoln, Nebraska making the inspection were: R. S. Decker, Geotechnical; Garold Ulmer and Gordon Jamison, Hydrology and Hydraulics. Mr. McPheeters accompanied the inspection team.

b. Dam.

- (1) Geology and Soils (abutment and embankment). This dam is located in the dissected till plains of the Central Lowlands Physiographic Area. The dam was constructed in a deep, near vertical banked gully cut through the loess and till that is typical of the loess hills adjacent to the Missouri River. Abutments consist of 5 to 15 feet of loess (CL) overlying 2 to 5 feet of glacial till (CL) overlying shale bedrock of the Kansas City group, Missourian Series, Pennsylvanian System. This shale is exposed downstream from the dam. The alluvium (CL) across the narrow valley bottom is estimated to be 2 to 5 feet thick.

Materials in the embankment consist of CL loessial soils borrowed from the valley banks and abutments upstream from the dam.

- (2) Upstream Slope. The upstream slope is well vegetated with adapted grasses. Some erosion was observed along the waterline but nothing significant. No cracks, slumps or other deformations were observed on the upstream slope. Photos 2 and 3 show the upstream slope.
- (3) Crest. The crest serves as a farm road which is bare. Good grass vegetation covers the crest along both sides of the roadway. Measurements shown on Plate C-1 show that the crest is mounded in the center and 2 to 3 feet lower at each end. This overfill in the center portion of the dam was constructed to accomodate anticipated settlement. No cracks, slumps or abnormal deformations were observed on the crest. Photo No. 4 shows the crest.
- (4) Downstream Slope. The downstream slope is well vegetated with brome and other grasses as shown in Photo No. 5. No cracks, deformations, or rodent activity were observed on the slope. Seepage outcrops in the lower section (elevation 871+) of the right abutment trough. (Mr. McPheeters says this is coming through the shale bedrock which was exposed

in that area). Seepage was clear and estimated at less than 0.1 gpm. The auger in Photo No. 11 is at the upper end of the seep in the right abutment trough. Seepage also outcrops (at elevation 871) along and outside of the downstream toe from about station 2+75 to 3+50 +. All seepage is clear and ponded. Mr. McPheeters reported that this area was wet prior to construction of the dam, the result of a spring and swamp drain coming into the valley from the north. Photo 21 shows the seep (swamp) area looking north. Willows in the background are the beginning of the swamp. There are 3 slumps or sink holes over the principal spillway pipe. The uppermost sink hole is about 50 feet (horizontally) upstream from the outlet end of the pipe. This sink is about 5-6 feet wide, 8-10 feet long (along the pipe) and 4 to 5 feet in depth. Photos 19 and 20 show this sink. Mr. McPheeters reported that a sink developed in about this same area about 5 years ago. At that time they excavated to the pipe, encased the pipe in concrete and refilled the hole. He also reported that the outlet pipe was extended 50 feet about 3 years after the dam was built. The original slump or sink and the present upper sink are in the area of the junction of the added pipe. Two other smaller slumps or sinks occur over the spillway pipe downstream from the upper, large sink described above. Photo 18 shows the 3 slumps looking up slope. The auger is in the lower slump. The rod is in the upper slump. Mr. McPheeter did not know when the present slumps developed.

c. Appurtenant Structures.

- (1) The principal spillway is uncontrolled. It consists of a 48-inch corrugated metal pipe riser which is 5.5 feet in height. The riser is connected to a 36-inch diameter corrugated metal pipe conduit. The metal riser and the outlet of the pipe appear to be in good condition. The entrance (crest) of the riser is almost completely covered with logs and trash, some of which are lodged down in the riser. Photos 11 and 12 show the inlet to the riser (the rod is near the center of the pipe). Photos 14 and 15 show the outlet. As discussed in paragraph b.4, the outlet of the spillway was extended 50 feet about 3 years after it was installed. At that time a 3-inch perforated plastic drain pipe was installed under the pipe extension. The outlet for this drain was submerged when observed, and it is not known whether or not it is functioning. Photo No. 15 shows the outlet ends of the pipe and the drain.
- (2) The emergency spillway is uncontrolled and cut through the left abutment. It is only partially vegetated but is not eroded. The spillway has a parabolic section and a fairly level profile as shown on Plate C-2. Photos 6 and 7 show the emergency spillway channel. The spillway exits over the

edge of the valley into an eroded headcut about 150 feet downstream from the centerline of the dam. The bottom of the head cut and gully is about 25 feet, (near vertically) below the ground surface. Shale is exposed in the bottom of the gully some 30-40 feet downstream from the face of the head cut. Photos 8 and 9 show the face of the head cut and the gully downstream from the head cut.

The area on the right end of the dam is lower than the embankment crest and would serve as a supplemental spillway.

- (3) Drawdown Facility - There are no drawdown facilities for this dam.
- d. Reservoir Area. No significant erosion was noted around the waterline part of which is shown in Photo No. 10. Mr. McPheeters reported that a great deal of sediment has accumulated in the reservoir and that the capacity of the reservoir has been reduced by 20-25%. The reservoir originally extended 150 to 170 feet farther up stream than at present.
- e. Downstream Channel. The downstream channel is fairly open and apparently stable since shale outcrops in the bottom of the channel downstream from the dam. Photos 13 and 16 show the downstream channel.

3.2 EVALUATION

This structure appears to be in poor condition due largely to the slumps or sinks over the spillway pipe and also due to the potential for breaching the reservoir by the encroaching head cut and gully at the exit of the emergency spillway. It would appear that the sink holes over the spillway pipe result from leakage through and/or around the pipe.

Trash should be removed from the inlet of the principal spillway.

Seepage along the toe and right abutment trough are apparently coming through shale bedrock and do not appear to impair the integrity of the dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no controlled outlet works for this dam. The pool level is controlled by rainfall, evaporation, infiltration, and the capacity of the uncontrolled spillways.

4.2 MAINTENANCE OF DAM

Maintenance of the structure appears to be minimal. The inlet of the principal spillway is covered with logs and trash, and the slumps over spillway pipe have apparently been there for some time (at least the lower two slumps are pretty well healed, the upper slump is quite raw). Mr. McPheeters reported that the downslope was mowed annually, and it is not known why the slumps over the pipe have not been previously observed. There did not appear to be any recent effort to stabilize or control the head cut at the emergency spillway exit.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no warning system in effect for this dam.

4.5 EVALUATION

No operational procedures exist for this dam. The lack of routine maintenance and repair is responsible for the poor condition of the dam. There appears to be considerable potential of failure of this structure if the spillways should flow to capacity for any length of time.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

- a. Design Data. No design data were found for this dam.
- b. Experience Data. The drainage area, reservoir surface area, and elevation-storage data were developed from the USGS St. Joseph South, MO.-KANS., 7 1/2 minute topographic quadrangle map. The hydraulic computations for the spillway and dam overtopping discharge ratings were based on data collected in the field at the time of the field inspection.
- c. Visual Observations.
 - (1) The principal spillway is completely surrounded and covered with tree limbs and trunks rendering it very inefficient. This trash should be removed immediately and an effort made to keep it clean.
 - (2) The head cut 150 feet below the emergency spillway crest is developing into a dangerous situation and should be watched closely.
 - (3) There are several slumps or holes that have developed on the back slope over the principal spillway pipe. These washouts have exposed the pipe. This is another item that deserves immediate attention.
- d. Overtopping Potential. The spillways are too small to pass 50% of the probable maximum flood without overtopping. The spillways will not pass the 10% probability flood, but will pass 8% of the probable maximum flood without overtopping the dam. Overtopping is dangerous because the flow of water over the crest will erode the face of the dam and, if continued long enough, will breach the dam with sudden release of all of the impounded water into the downstream floodplain.

From Plate No. C-1 it can be seen that this dam was constructed with a very high crown (approximately 2.5 feet difference between minimum-top-of-dam and crown). The figures given in the table below appear deceiving because of this. It should also be noted that water begins to flow out of the reservoir over the right (south) bank at the approximate same elevation as minimum-top-of-dam.

The PMF was routed with an open principal spillway and also with a completely plugged spillway. The table below shows the differences in the results.

The results of the routings through the dam are tabulated in regards to the following conditions:

<u>Frequency</u>	<u>Inflow Discharge c.f.s.</u>	<u>Outflow Discharge c.f.s.</u>	<u>Maximum Pool Elevation</u>	<u>* Maximum Depth Over Dam Feet</u>	<u>Duration Over Top Hours</u>
10%	990	750	895.3	0.6	1
1/2 PMF	3780	3720	896.9	2.2	6
* PMF	3780	3720	897.0	2.3	6 +
* PMF	7560	7510	897.8	3.1	9 +
* PMF	7560	7510	897.9	3.2	11 +
0.08 PMF	570	400	894.7	0	--
*0.05 PMF	360	270	894.7	0	--

* - Principal Spillway plugged.

** - Minimum Top Dam Elevation - 894.7.

According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, this dam is classified as having a high hazard rating and a small size. Therefore, the 1/2 PMF to PMF is the test for the adequacy of the dam and its spillway.

The estimated damage zone is described in Paragraph 1.2d in this report.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

- a. Visual Observation. This dam appears to be structurally stable from the standpoint of shear strength. However, the stability of the dam is questionable from the standpoint of what appears to be internal erosion that is causing piping or slumping along the principal spillway pipe.

Prolonged and/or frequent flows through the emergency spillway would cause accelerated head cutting of the gully at the exit of the emergency spillway which could result in breaching of the reservoir.

- b. Design and Construction Data. No design or construction data were available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.
- c. Operating Records. There are no controlled operating facilities for this dam.
- d. Post Construction Changes. The owner reported that the principal spillway pipe was extended 50 feet about 3 years after the dam was constructed. He also reported that a slump over the pipe (in the area of the pipe extension) was repaired about 5 years ago.
- e. Seismic Stability. This dam is located in Seismic Zone 1. An earthquake of the magnitude predicted in this area is not expected to cause structural failure of this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

- a. Safety. This dam is in poor condition and appears to have a serious potential of failure. The approximate analyses performed for this report indicate that it is not hydrologically adequate. The spillways will not pass the 10% probability flood and will pass only 8% of the probable maximum flood without overtopping the low sections of the dam. Continued internal erosion and slumping along the spillway pipe could result in failure of the dam. The causes of the slumps should be determined and remedied. Blockage of the principal spillway inlet certainly minimizes its operation, however, the effects of principal spillway flow are minor with respect to the overtopping potential. Prolonged and/or high flows in the emergency spillway would accelerate headward erosion of the gully at the spillway exit which could breach the reservoir. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.
- b. Adequacy of Information. Due to the lack of engineering data, the conclusions in this report are based upon performance history and visual observations. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which is considered a deficiency. However, the dam has been in place for 11 years and has withstood what must have been near maximum stresses without deformation, shear failure or piping from seepage pressures. (The owner reported that 3 to 4 feet of water passed through the spillway in 1972 or 1973. Hydrologic analysis indicate that the 0.5 PMF will overtop the low sections of the dam by 2.2 feet to elevation 897 +).
- c. Urgency. A program should be developed as soon as possible to monitor at regular intervals the deficiencies described in this report. The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. The item recommended in paragraph 7.2.a should be pursued on a high priority basis.
- d. Necessity for Further Investigations. The additional studies and analyses recommended in paragraph 7.2b should be accomplished by the owner on a high priority basis.
- e. Seismic Stability. This dam is located in Seismic Zone 1. An earthquake of this magnitude is not expected to be hazardous to this dam. It is recommended, however, that the prescribed seismic loading for Seismic Zone 1 be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a registered professional engineer experienced in the design and construction of earth dams.

a. Alternatives.

- (1) The spillway size and/or the height of dam should be increased to pass 50 percent of the probable maximum flood without overtopping the dam.

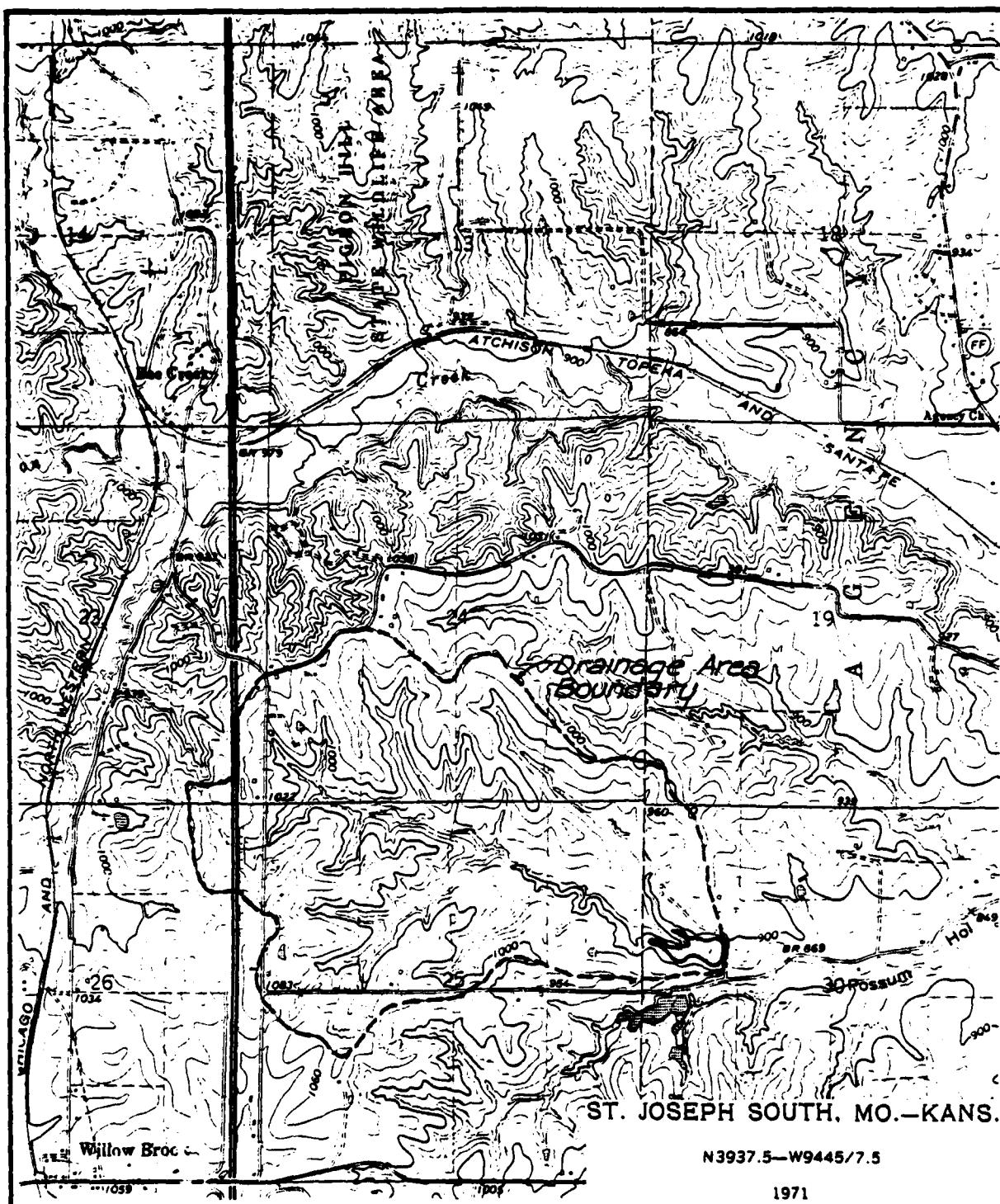
b. Operation and Maintenance Procedures.

- (1) Additional studies should be made to determine the present maximum capacity of the reservoir and the damages that would result from failure of this dam.
- (2) Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" should be performed and made a matter of record.
- (3) The causes (s) of slumping over the principal spillway pipe should be determined and remedial measures taken to correct the problem.
- (4) Stabilizing and/or controlling the head cut and gully at the exit of the emergency spillway is not practical for this project (This would probably require a concrete drop or chute; another dam downstream; etc.). It is recommended, however, that the headward progress of the gully be regularly monitored and that these records be made a part of this project file.

Diverting the runoff from the farmland adjoining the spillway on the left (north) side would aid in reducing the headward progress of the gully.

- (5) The inlet to the principal spillway should be cleared and measures taken to prevent logs and trash from blocking the spillway.
- (6) The main channel of the emergency spillway should be vegetated.
- (7) Regular mowing of the embankment slopes should be continued.

APPENDIX A
MAPS



Scale in feet
2000 1000 0 2000 4000

Contour Interval - 20'



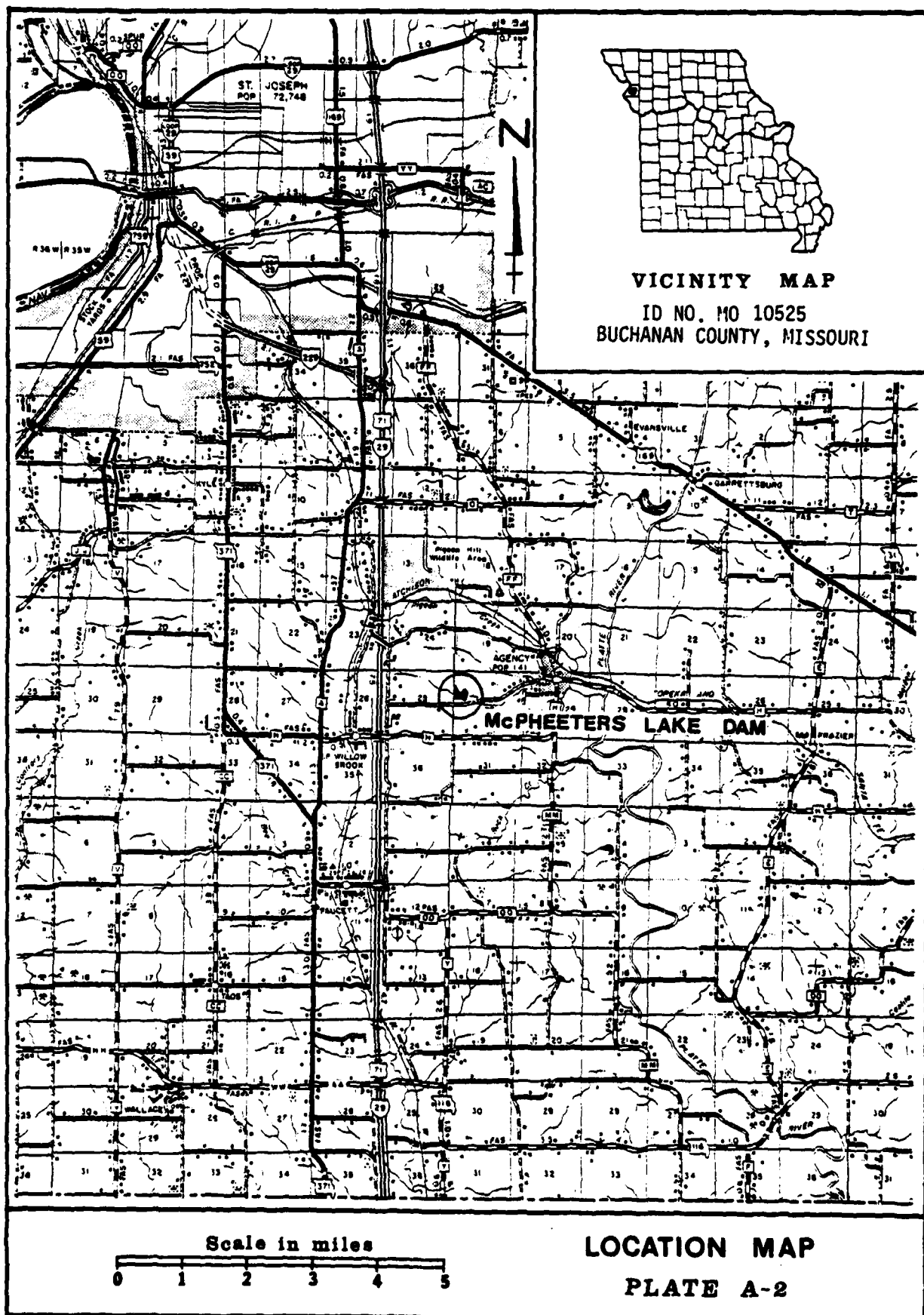
VICINITY TOPOGRAPHY

McPHEETERS LAKE DAM

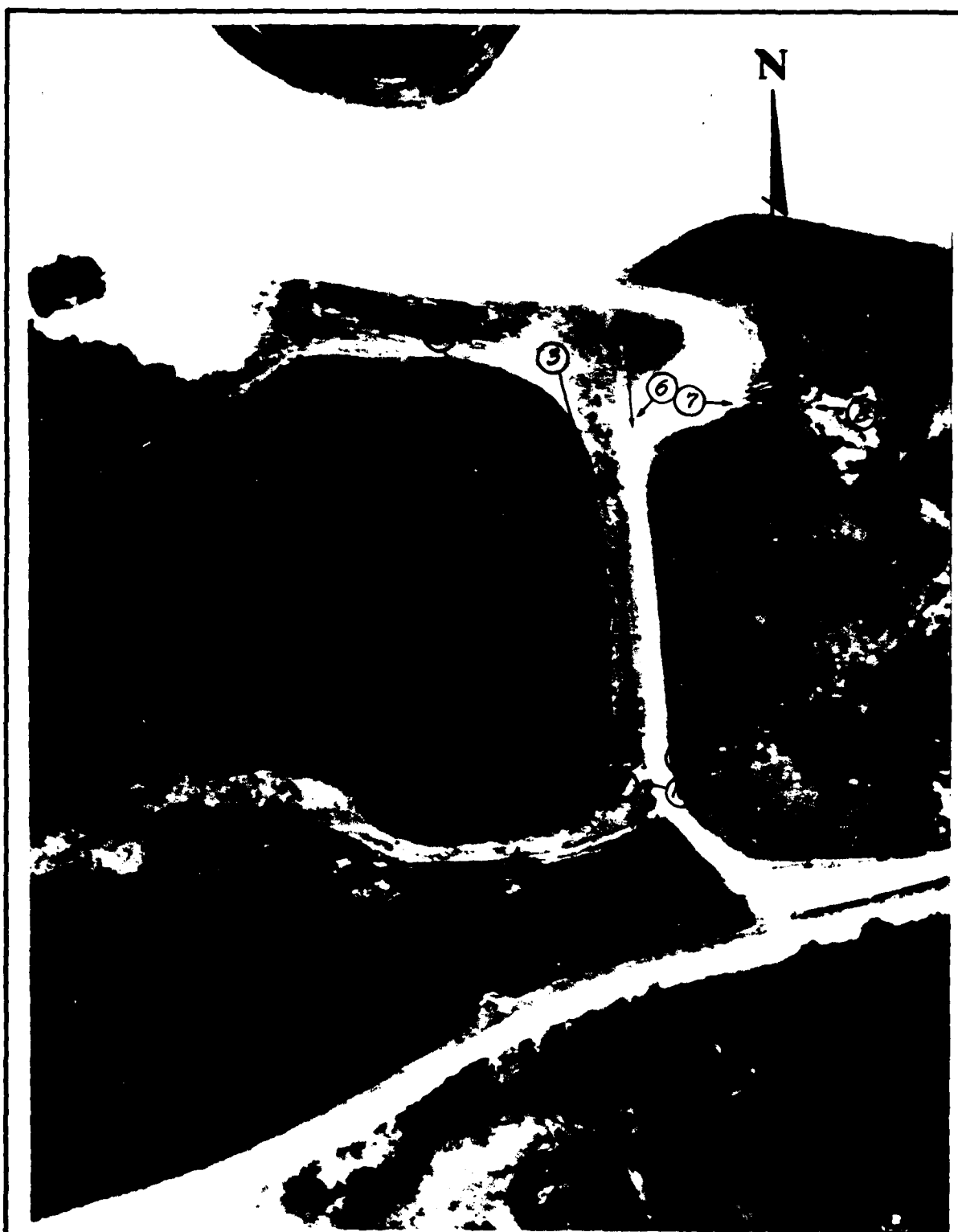
BUCHANAN COUNTY, MISSOURI

MO. 10525

PLATE A-1



APPENDIX B
PHOTOGRAPHS



McPHEETERS DAM
BUCHANAN COUNTY, MISSOURI
MO 10525

PHOTO INDEX

PLATE B-1

FRONT

FRONT



PHOTO NO. 2 - OVERVIEW FROM HIGH ON LEFT SIDE

FORM 2



PHOTO NO. 3 - UPSTREAM SLOPE FROM LEFT ABUTMENT



PHOTO NO. 4 - CREST FROM LEFT ABUTMENT, EMERGENCY SPILLWAY IN FOREGROUND



PHOTO NO. 5 - DOWNSTREAM SLOPE FROM LEFT END

REPL.

FROM



PHOTO NO. 6 - VIEW UPSTREAM IN EMERGENCY SPILLWAY



PHOTO NO. 7 - VIEW DOWNSTREAM IN EMERGENCY SPILLWAY

FORM 6

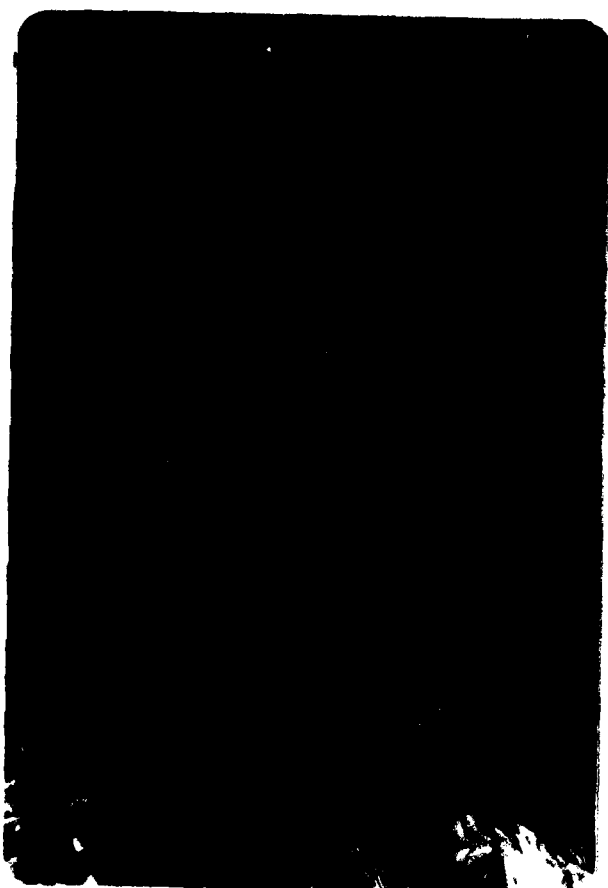


PHOTO NO. 8 - VIEW LOOKING
INTO THE FACE OF THE HEAD
CUT AT END OF EMERGENCY
SPILLWAY



PHOTO NO. 9 - LOOKING DOWNSTREAM IN THE GULLEY AT END OF EMERGENCY
SPILLWAY.

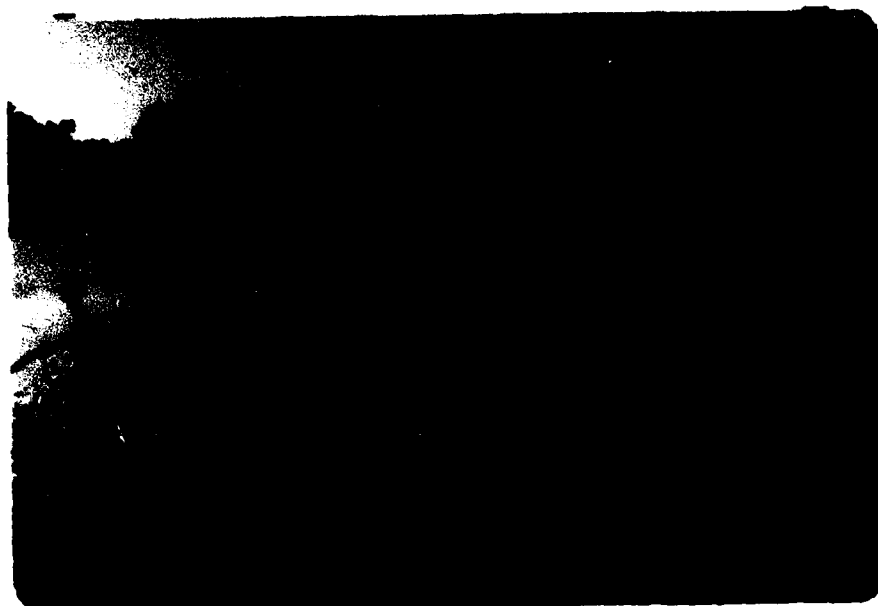


PHOTO NO. 10 - VIEW UPSTREAM ACROSS PRINCIPAL SPILLWAY RISER

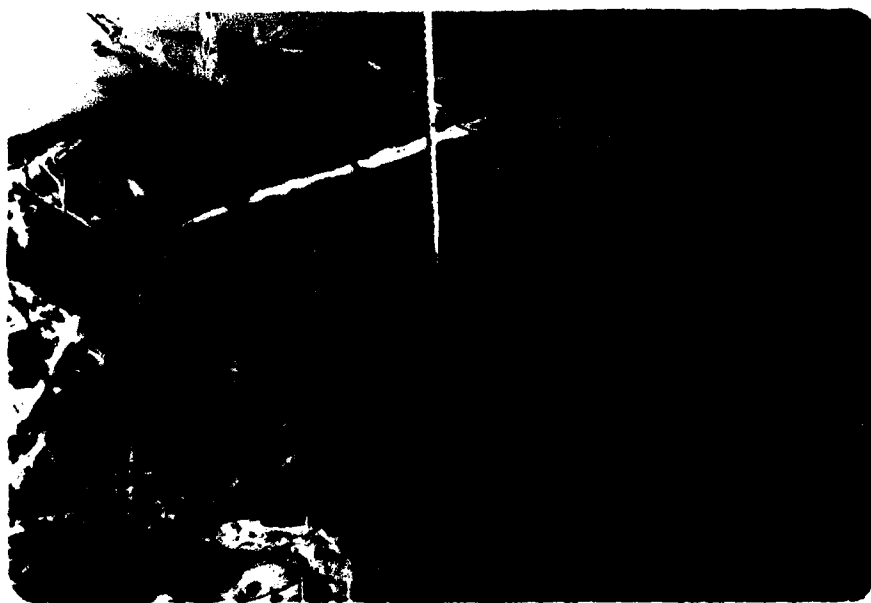


PHOTO NO. 11 - PRINCIPAL SPILLWAY RISER OBSCURED BY DEBRIS.
ROD AT APPROXIMATE CENTER



PHOTO NO. 12 - VIEW INTO RISER OF PRINCIPAL SPILLWAY

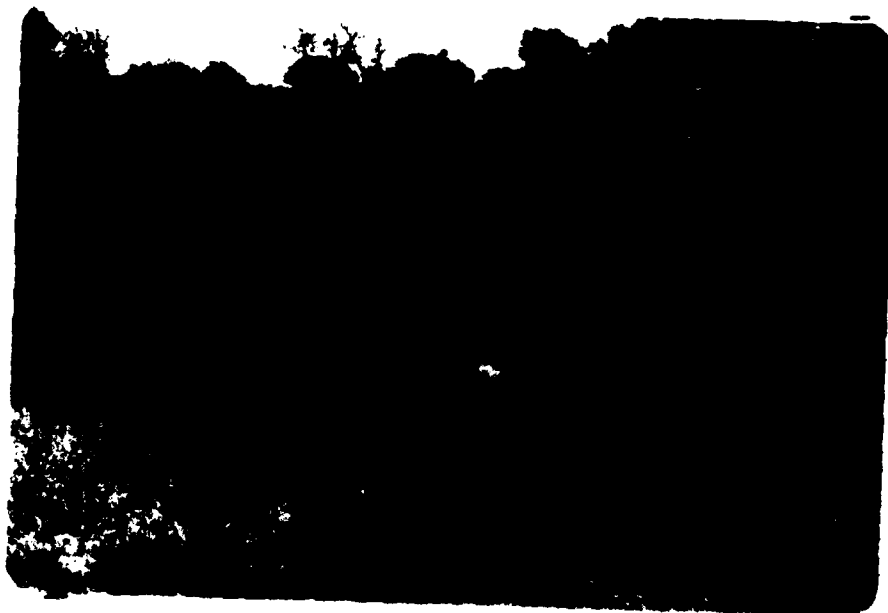


PHOTO NO. 13 - VIEW DOWNSTREAM FROM RIGHT SIDE

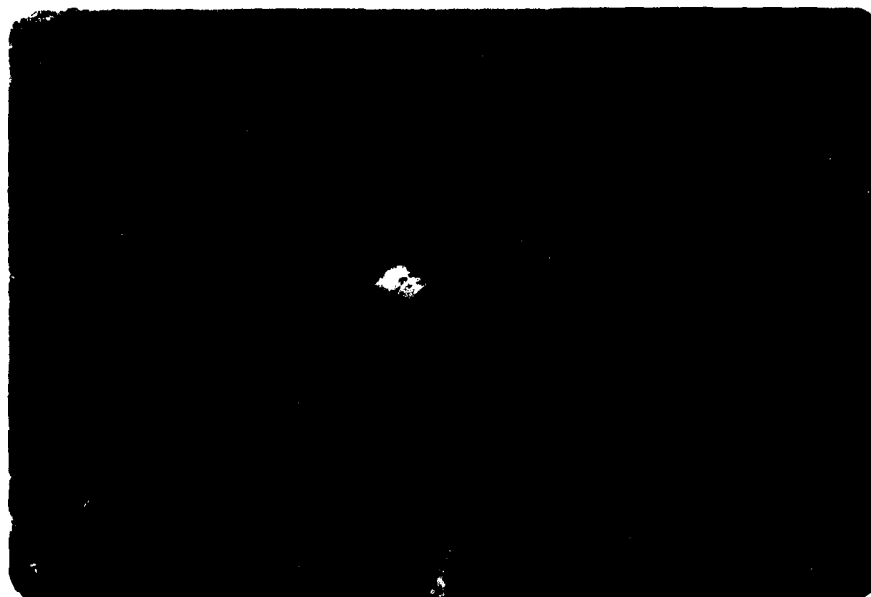


PHOTO NO. 14 - PRINCIPAL SPILLWAY OUTLET



PHOTO NO. 15 - PRINCIPAL SPILLWAY OUTLET SHOWING 3" PLASTIC DRAIN DIRECTLY UNDER PIPE

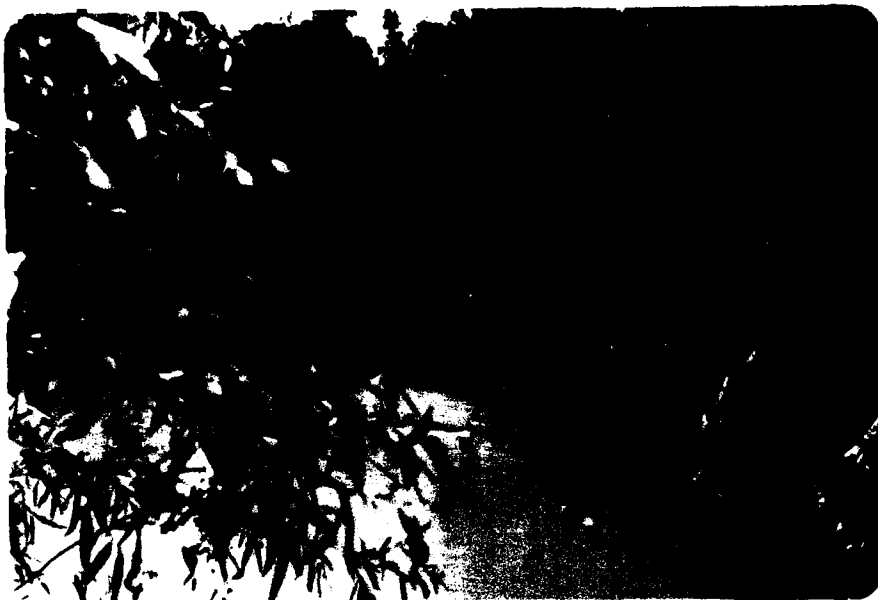


PHOTO NO. 16 - VIEW OF DOWNSTREAM CHANNEL FROM PRINCIPAL
SPILLWAY OUTLET.



PHOTO NO. 17 - SEEPAGE AREA
IN RIGHT ABUTMENT TROUGH.
AUGER AT UPPER END OF SEEP.



PHOTO NO. 18 - AREA OF
SLUMPS OVER PRINCIPAL
SPILLWAY



PHOTO NO. 19 - SLUMP
OVER PRINCIPAL SPILLWAY
PIPE, ROD SETTING ON
TOP OF EXPOSED PIPE



PHOTO NO. 20 - ADDITIONAL VIEW OF SLUMP SHOWN IN PHOTO NO. 18



PHOTO NO. 21 - SEEP AT TOE, VIEW LOOKING TO LEFT (NORTH)

FROM



PHOTO NO. 22 - SERVICE STATION AT AGENCY SHOWING STAFF GAUGE ON LIGHT POLE

FROM 2

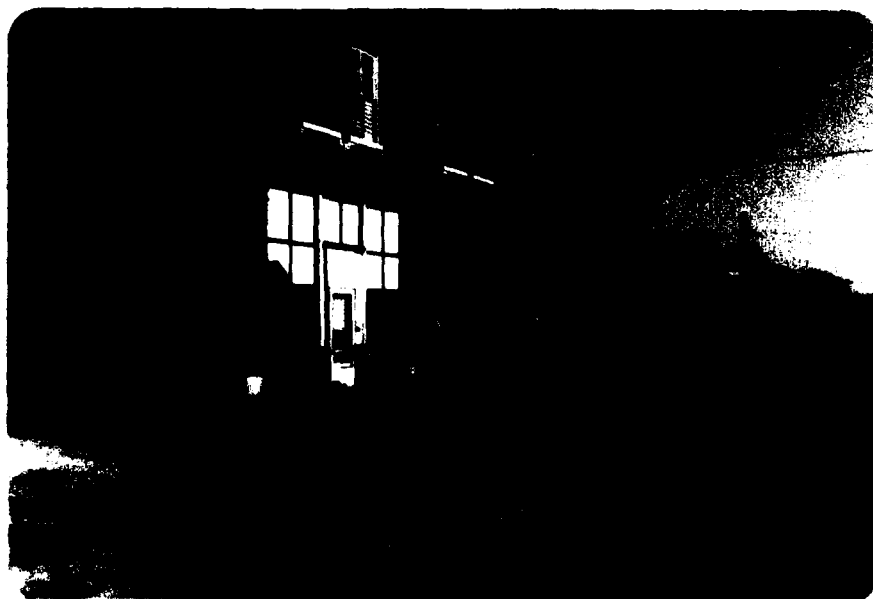


PHOTO NO. 23 - BUILDING IN AGENCY. NOTE HIGH WATER MARKS



PHOTO NO. 24 - RIGHT SIDE OF POSSUM HOLLOW CREEK NEAR AGENCY



PHOTO NO. 25 - LEFT SIDE OF POSSUM HOLLOW CREEK NEAR AGENCY

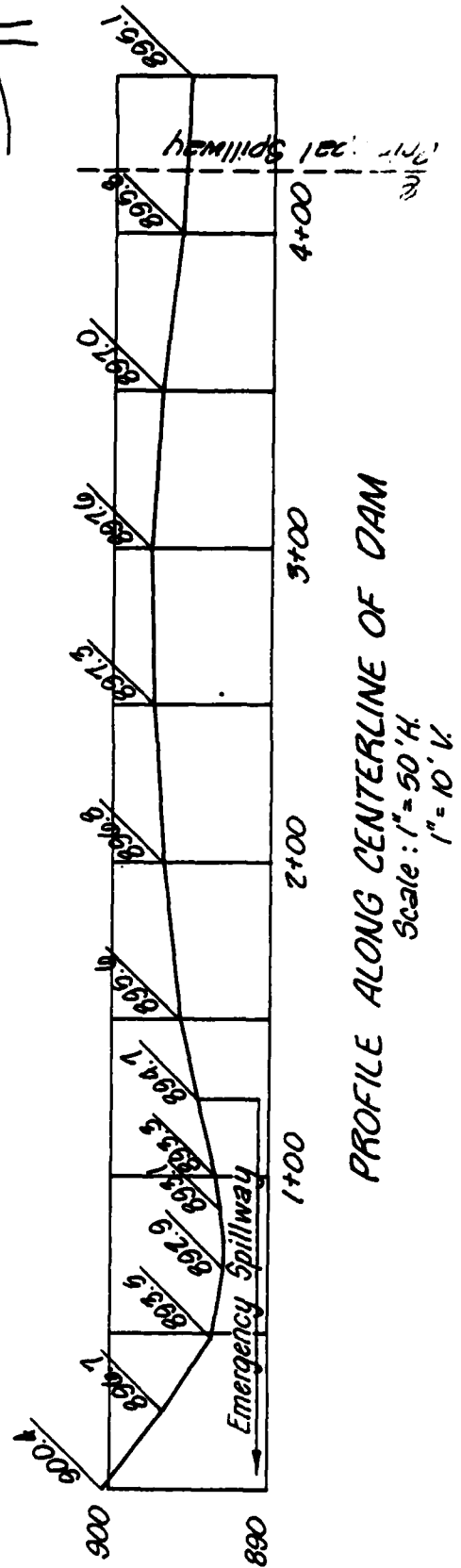
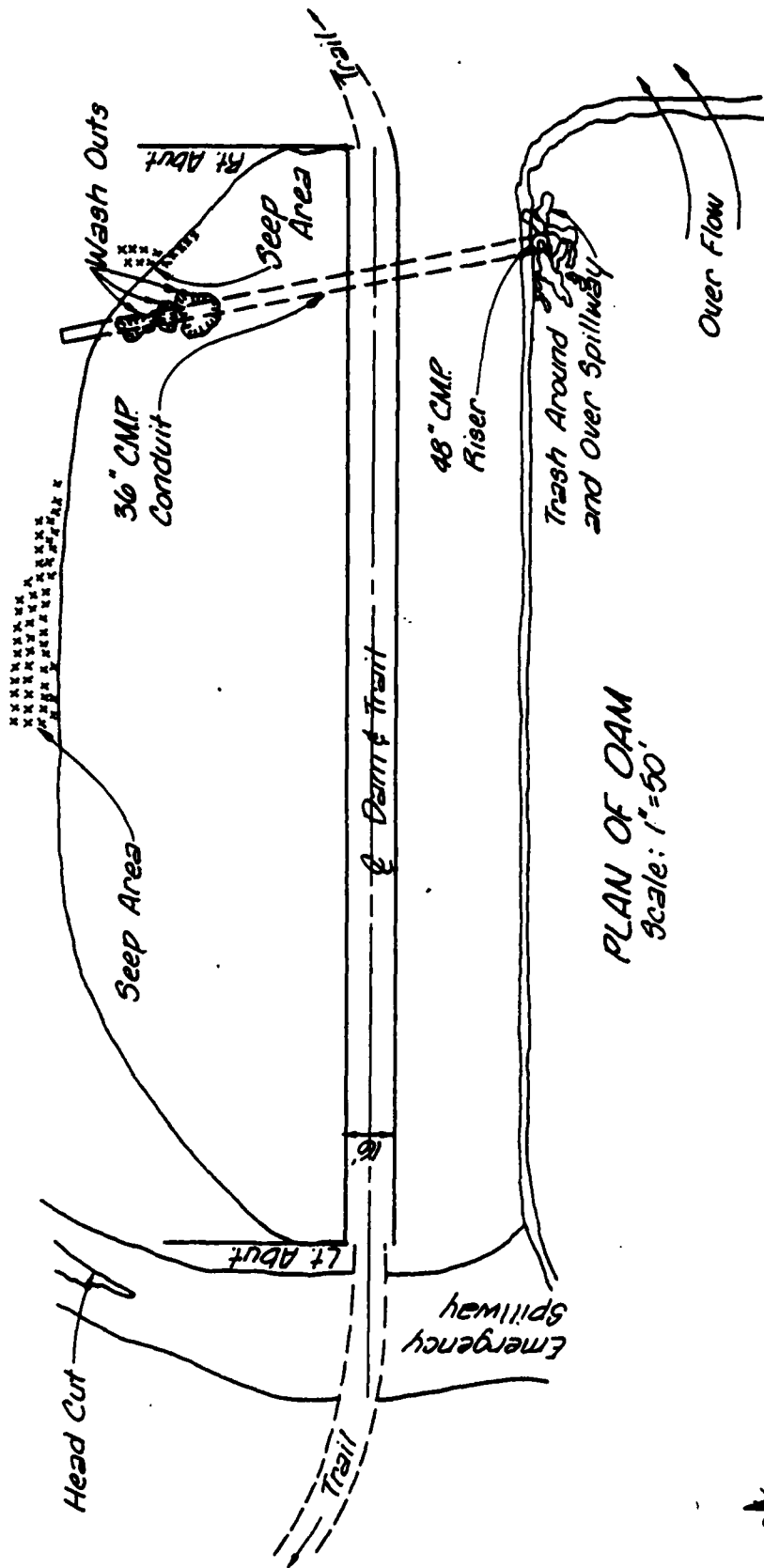


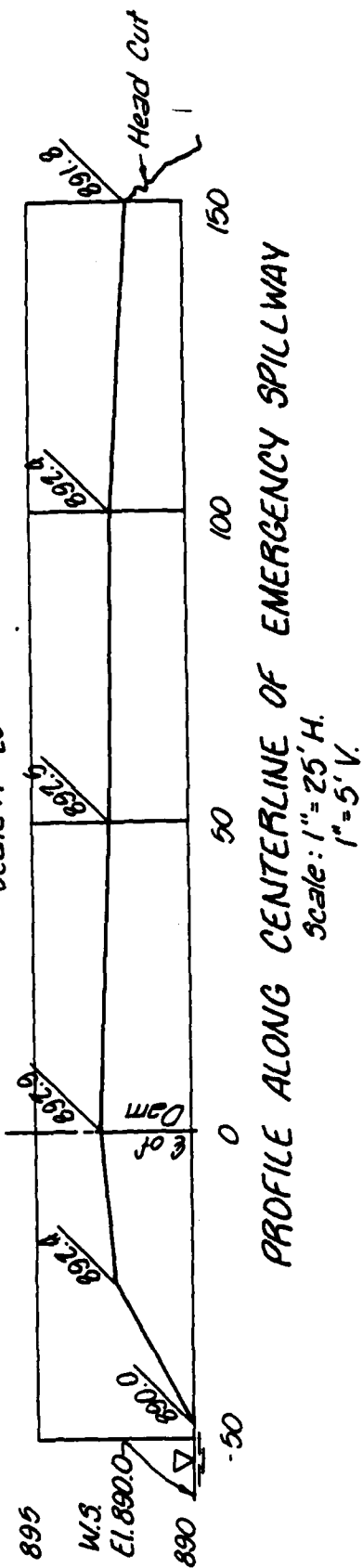
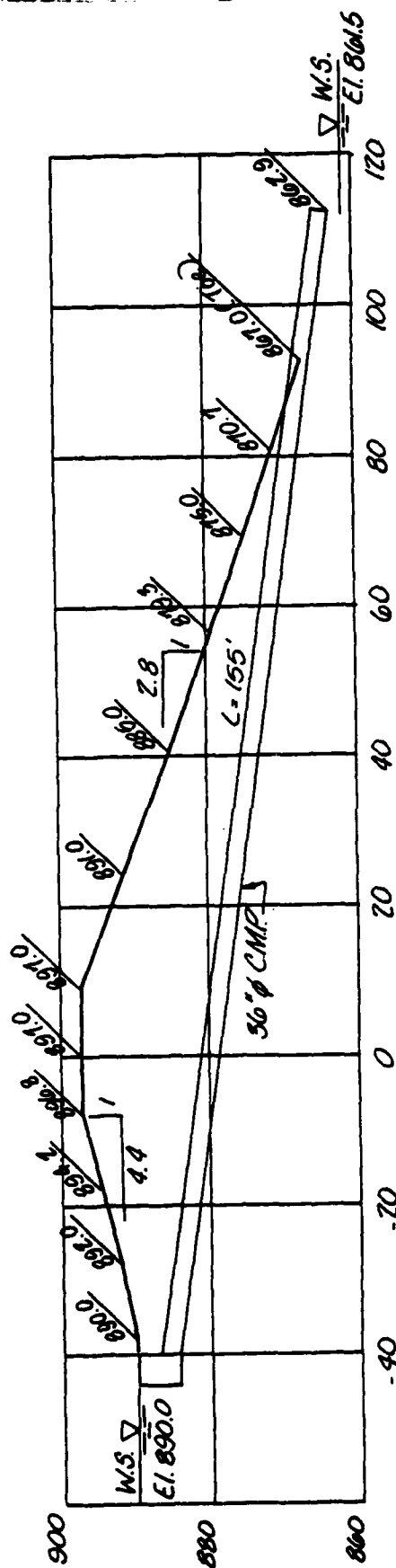
PHOTO NO. 26 - TRAILER HOUSE IN FLOODPLAIN DOWNSTREAM FROM
DAM APPROXIMATELY ONE-QUARTER MILE



PHOTO NO. 27 - HOUSES ON WEST EDGE OF AGENCY

APPENDIX C
PROJECT PLATES





APPENDIX D
HYDRAULIC AND HYDROLOGIC DATA

HYDROLOGIC/HYDRAULIC COMPUTATIONS

1. The SCS dimensionless unit hydrograph and the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Corps of Engineers, Davis, California, were used to develop the inflow hydrographs (See this Section).
 - a. Twenty-four hour, one percent probabilistic rainfall for the dam location was taken from the data for the rainfall station at Kansas City, MO. as supplied by the St. Louis District, Corps of Engineers per their letter dated 4 March 1980. The twenty-four hour probable maximum precipitation was taken from the curves of Hydrometeorological Report No. 33 and current Corps of Engineers and St. Louis policy and guidance for hydraulics and hydrology.
 - b. Drainage area = 0.963 square miles (616.5 acres).
 - c. Time of concentration of runoff = 39 minutes (computed from the "Kirpich" formula).
 - d. The antecedent storm conditions for the probable maximum precipitation were heavy rainfall and low temperatures which occurred on the previous 5 days (SCS AMC III). The antecedent storm conditions for the one percent probabilistic precipitation were an average of the conditions which have preceded the occurrence of the maximum annual flood on numerous watersheds (SCS AMC II). The initial pool elevation was assumed at the invert of the principal spillway.
 - e. The total twenty-four hour storm duration losses for the one percent probabilistic storm were 3.25 inches. The total losses for the PMF storm were 1.87 inches. These data are based on SCS runoff curve No. 72 and No. 86 for antecedent moisture conditions SCS AMC II and AMC III respectively. The watershed is composed of primarily SCS soil group B (Knox-Judson McPaul Soil Association) and consists of approximately 55% pasture and woods and the remainder in straight row crops and legumes partially contoured.
 - f. Average soil loss rates = 0.05 inch per hour approximately (For PMF storm, AMC III).
2. The combined discharge rating consisted of three components: the flow through the principal spillway, the flow through the emergency spillway, the flow going over the top of the dam, and the flow bypassing the dam by overflowing the right bank of the reservoir.
 - a. The principal spillway rating was developed by using the weir and orifice equations.

(1) Weir Flow equation ($Q = CLH^{1.5}$)

where C = weir coefficient = 3.4 (from SCS Engr. Memo 50)

L = effective weir length, ft. = 12.6

H = total head, ft.

(2) Orifice equation - $Q = CA\sqrt{2gh}$

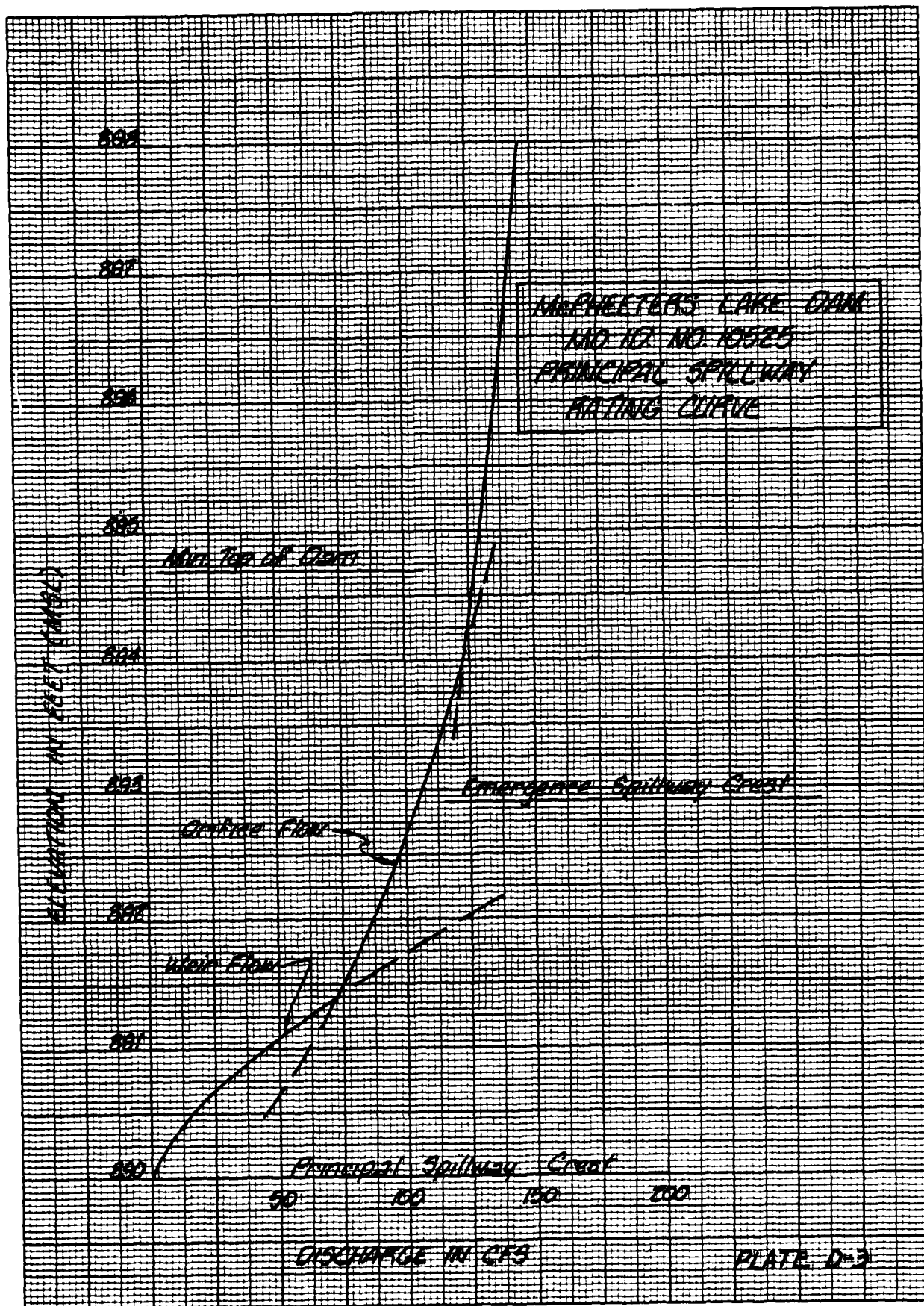
where C = orifice coefficient = 0.6 (standard)

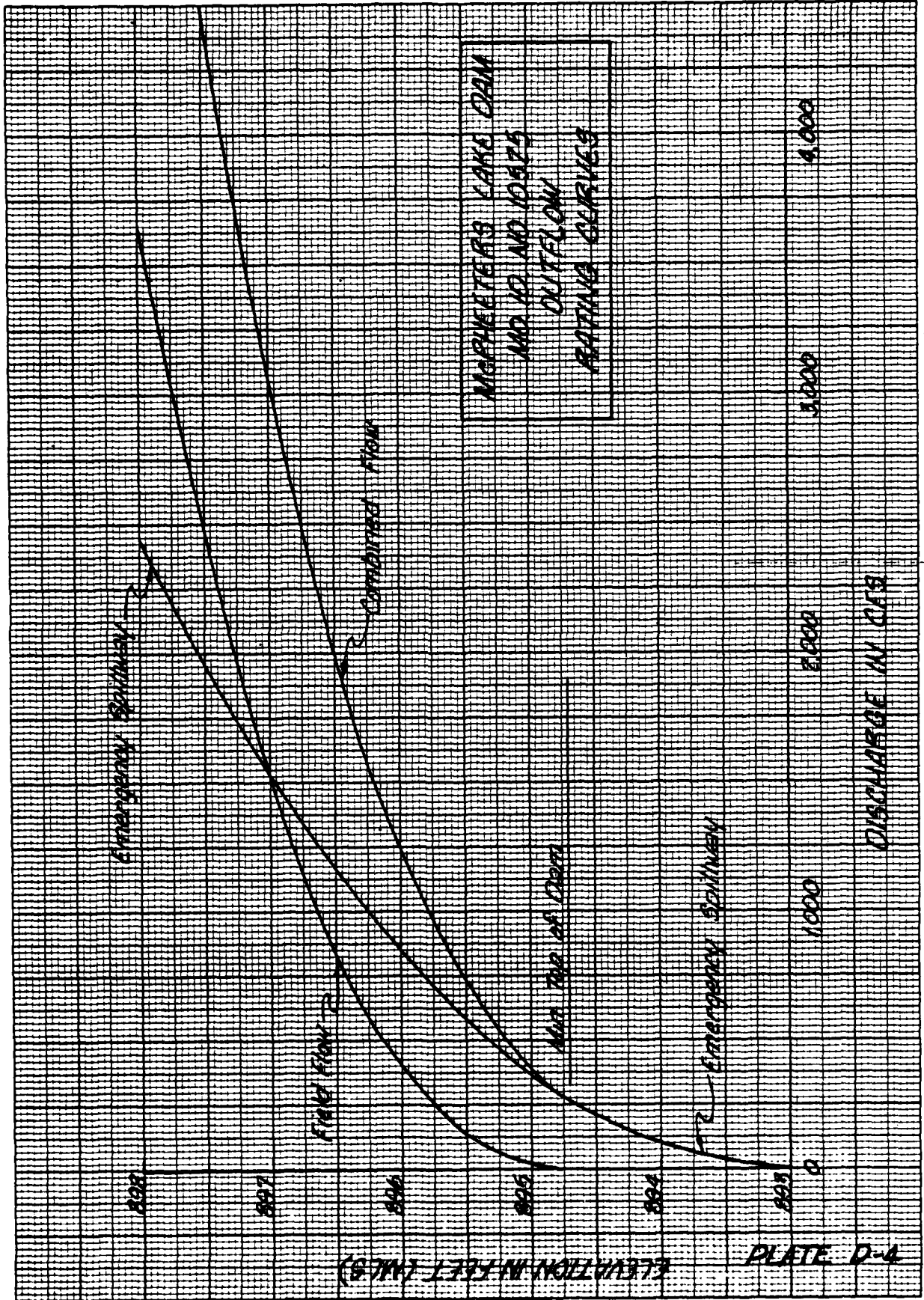
A = area of riser, sq. ft. = 12.6

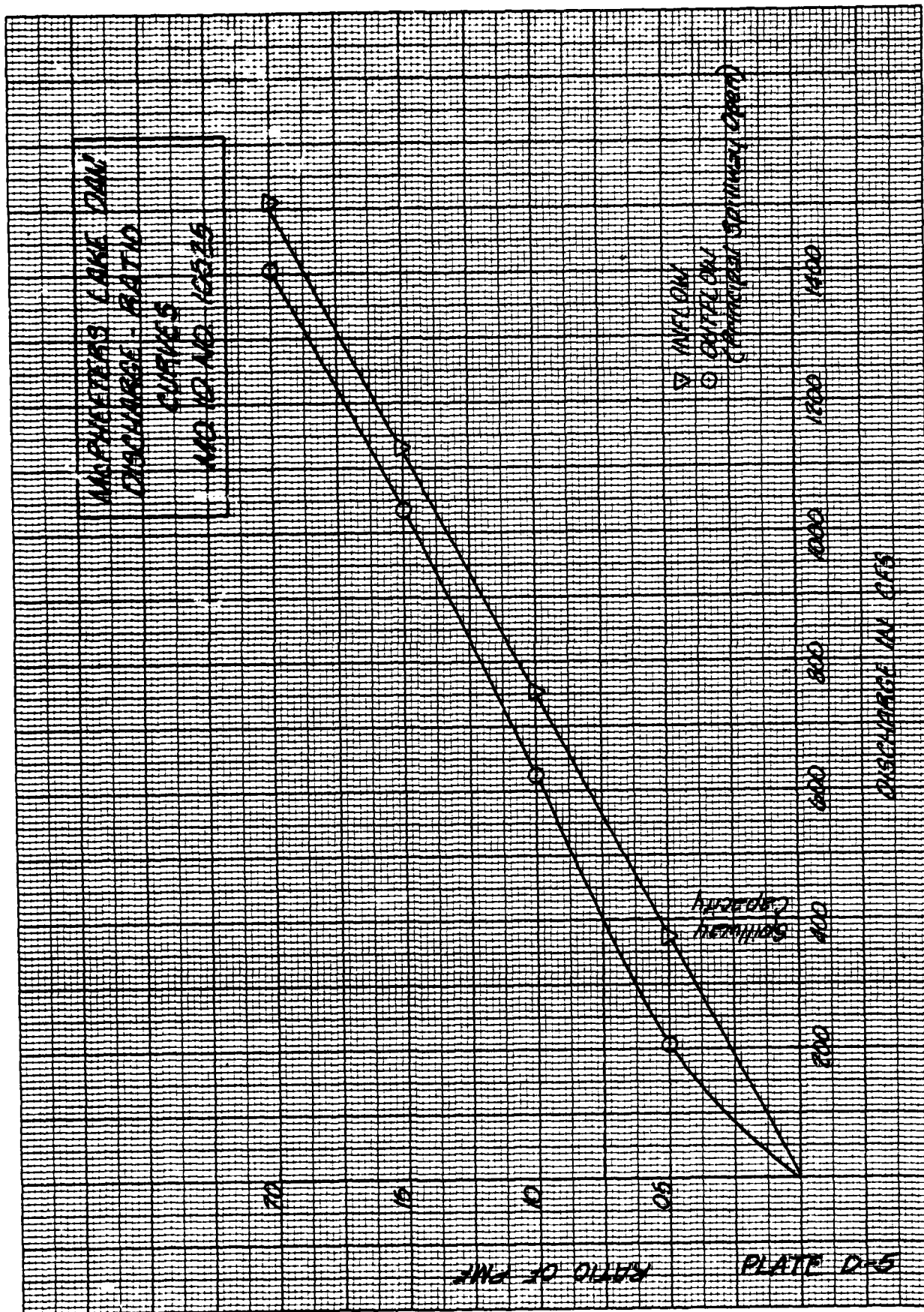
A = area of conduit, sq. ft. = 7.07

h = total head, ft.

- b. The emergency spillway rating curve was developed using the Corps of Engineers, Water Surface Profile HEC-2 computer program assuming critical depth at the head cut.
 - c. The flows over the dam were determined by using the dam overtopping analyses (irregular top of dam) within the HEC-1 (Dam Safety Version) program.
3. Floods were routed through the reservoir using the HEC-1 (Dam Safety Version) program to determine the capabilities of the spillway and dam embankment crest. The input, output and plotted hydrographs are attached in this Section.







 FLOOD HYDROGRAPH PAF (HED-1)
 DAM SAFETY VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79

RUN DATE# 80/07/09.
 TIME# 16.44.05.

MC PHEETERS LAKE DAM - NO. ID. NO. 10525
 SAFETY ANALYSIS OF DAM OVERTOPPING USING ASSIGNED FLOOD FREQUENCIES
 H & H ANALYSIS BY ROUTING PMF RATIOS THRU THE RESERVOIR

JOB SPECIFICATION									
NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	3	0
		JOPER	NMT	LROPT	TRACE				
		5	0	0	0				

MULTI-PLAN ANALYSES TO BE PERFORMED

RTIOS= .05 .10 .15 .20 .35 .50 .75 1.00
 MPLAN= 1 NRTIO= 8 LRTIO= 1

SUB-AREA RUNOFF COMPUTATION

CALCULATION OF INFLOW HYDRO TO MCPHEETERS RESERVOIR

ISTAG	ICOMP	IECON	ITAPE	JFLT	JFRT	INAME	ISAME	LOCAL	IAUTO
000001	0	0	0	0	0	1	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	24.20	102.00	121.00	130.00	0.00	0.00	0.00

LOSS DATA

LROFT	STKR	DLTKR	RTIOL	ERAIN	STKRS	RTICK	STRTL	CNSTL	ALSHX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-86.00	0.00	0.00

CURVE NO = -86.00 WETNESS = -1.00 EFFECT CN = 86.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAG= .39

RECESSION DATA

STRTQ= 0.00 GRCSN= -.01 RTIOR= 1.00

UNIT HYDROGRAPH 26 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .39 VOL= 1.00									
101.	312.	660.	941.	1069.	1028.	884.	682.	471.	342.
256.	188.	137.	100.	73.	53.	39.	29.	21.	15.
11.	9.	6.	4.	2.	0.				

NO. DA	HR. MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	END-OF-PERIOD FLOW	IR. MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.21	.19	.01	459.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.21	.19	.01	502.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.21	.20	.01	591.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.21	.20	.01	721.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.21	.20	.01	845.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.21	.20	.01	1005.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.21	.20	.01	1126.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.21	.20	.01	1221.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.21	.20	.01	1287.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.21	.20	.01	1336.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.21	.20	.01	1373.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.21	.20	.01	1402.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.25	.24	.01	1427.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.25	.24	.01	1456.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.25	.24	.01	1495.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.25	.24	.01	1543.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.25	.24	.01	1593.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.25	.24	.01	1641.
1.01	1.35	19	.01	0.00	.01	0.	1.01	13.35	163	.25	.24	.01	1681.
1.01	1.40	20	.01	0.00	.01	0.	1.01	13.40	164	.25	.24	.01	1713.
1.01	1.45	21	.01	0.00	.01	0.	1.01	13.45	165	.25	.24	.01	1736.
1.01	1.50	22	.01	0.00	.01	0.	1.01	13.50	166	.25	.24	.00	1753.
1.01	1.55	23	.01	0.00	.01	0.	1.01	13.55	167	.25	.24	.00	1766.
1.01	2.00	24	.01	0.00	.01	0.	1.01	14.00	168	.25	.24	.00	1776.
1.01	2.05	25	.01	0.00	.01	0.	1.01	14.05	169	.31	.30	.01	1790.
1.01	2.10	26	.01	0.00	.01	0.	1.01	14.10	170	.31	.30	.01	1815.
1.01	2.15	27	.01	0.00	.01	0.	1.01	14.15	171	.31	.30	.00	1859.
1.01	2.20	28	.01	0.00	.01	0.	1.01	14.20	172	.31	.30	.00	1921.
1.01	2.25	29	.01	0.00	.01	0.	1.01	14.25	173	.31	.30	.00	1989.
1.01	2.30	30	.01	0.00	.01	0.	1.01	14.30	174	.31	.30	.00	2055.
1.01	2.35	31	.01	0.00	.01	0.	1.01	14.35	175	.31	.30	.00	2111.
1.01	2.40	32	.01	0.00	.01	1.	1.01	14.40	176	.31	.30	.00	2154.
1.01	2.45	33	.01	0.00	.01	2.	1.01	14.45	177	.31	.30	.00	2185.
1.01	2.50	34	.01	0.00	.01	2.	1.01	14.50	178	.31	.30	.00	2208.
1.01	2.55	35	.01	0.00	.01	3.	1.01	14.55	179	.31	.31	.00	2225.
1.01	3.00	36	.01	0.00	.01	4.	1.01	15.00	180	.31	.31	.00	2238.
1.01	3.05	37	.01	0.00	.01	5.	1.01	15.05	181	.19	.19	.00	2235.
1.01	3.10	38	.01	0.00	.01	6.	1.01	15.10	182	.38	.37	.00	2224.
1.01	3.15	39	.01	0.00	.01	7.	1.01	15.15	183	.38	.37	.00	2209.
1.01	3.20	40	.01	0.00	.01	9.	1.01	15.20	184	.56	.56	.01	2239.
1.01	3.25	41	.01	0.00	.01	10.	1.01	15.25	185	.66	.65	.01	2361.
1.01	3.30	42	.01	0.00	.01	11.	1.01	15.30	186	1.59	1.58	.01	2685.
1.01	3.35	43	.01	0.00	.01	12.	1.01	15.35	187	2.63	2.61	.02	3408.
1.01	3.40	44	.01	0.00	.01	13.	1.01	15.40	188	1.03	1.03	.01	4556.
1.01	3.45	45	.01	0.00	.01	14.	1.01	15.45	189	.66	.65	.00	5959.
1.01	3.50	46	.01	0.00	.01	15.	1.01	15.50	190	.56	.56	.00	7079.
1.01	3.55	47	.01	0.00	.01	16.	1.01	15.55	191	.38	.37	.00	7562.
1.01	4.00	48	.01	0.00	.01	17.	1.01	16.00	192	.38	.37	.00	7448.
1.01	4.05	49	.01	0.00	.01	18.	1.01	16.05	193	.29	.29	.00	6869.
1.01	4.10	50	.01	0.00	.01	19.	1.01	16.10	194	.29	.29	.00	6012.
1.01	4.15	51	.01	0.00	.01	20.	1.01	16.15	195	.29	.29	.00	5123.
1.01	4.20	52	.01	0.00	.01	21.	1.01	16.20	196	.29	.29	.00	4405.
1.01	4.25	53	.01	0.00	.01	22.	1.01	16.25	197	.29	.29	.00	3840.
1.01	4.30	54	.01	0.00	.01	22.	1.01	16.30	198	.29	.29	.00	3394.
1.01	4.35	55	.01	0.00	.01	23.	1.01	16.35	199	.29	.29	.00	3057.
1.01	4.40	56	.01	0.00	.01	24.	1.01	16.40	200	.29	.29	.00	2809.
1.01	4.45	57	.01	0.00	.01	25.	1.01	16.45	201	.29	.29	.00	2628.
1.01	4.50	58	.01	0.00	.01	26.	1.01	16.50	202	.29	.29	.00	2496.
1.01	4.55	59	.01	0.00	.01	27.	1.01	16.55	203	.29	.29	.00	2401.

1.01	5.00	60	.01	.00	.01	27.	1.01	17.00	204	.29	.29	.00	2330.
1.01	5.05	61	.01	.00	.01	28.	1.01	17.05	205	.23	.23	.00	2273.
1.01	5.10	62	.01	.00	.01	29.	1.01	17.10	206	.23	.23	.00	2216.
1.01	5.15	63	.01	.00	.01	30.	1.01	17.15	207	.23	.23	.00	2149.
1.01	5.20	64	.01	.00	.01	30.	1.01	17.20	208	.23	.23	.00	2071.
1.01	5.25	65	.01	.00	.01	31.	1.01	17.25	209	.23	.23	.00	1989.
1.01	5.30	66	.01	.00	.01	32.	1.01	17.30	210	.23	.23	.00	1912.
1.01	5.35	67	.01	.00	.01	33.	1.01	17.35	211	.23	.23	.00	1846.
1.01	5.40	68	.01	.00	.01	33.	1.01	17.40	212	.23	.23	.00	1796.
1.01	5.45	69	.01	.01	.01	34.	1.01	17.45	213	.23	.23	.00	1764.
1.01	5.50	70	.01	.01	.01	35.	1.01	17.50	214	.23	.23	.00	1741.
1.01	5.55	71	.01	.01	.01	35.	1.01	17.55	215	.23	.23	.00	1724.
1.01	6.00	72	.01	.01	.01	36.	1.01	18.00	216	.23	.23	.00	1712.
1.01	6.05	73	.06	.03	.03	39.	1.01	18.05	217	.02	.02	.00	1683.
1.01	6.10	74	.06	.03	.03	47.	1.01	18.10	218	.02	.02	.00	1612.
1.01	6.15	75	.06	.03	.03	64.	1.01	18.15	219	.02	.02	.00	1471.
1.01	6.20	76	.06	.03	.03	89.	1.01	18.20	220	.02	.02	.00	1268.
1.01	6.25	77	.06	.04	.03	119.	1.01	18.25	221	.02	.02	.00	1044.
1.01	6.30	78	.06	.04	.03	149.	1.01	18.30	222	.02	.02	.00	829.
1.01	6.35	79	.06	.04	.03	177.	1.01	18.35	223	.02	.02	.00	644.
1.01	6.40	80	.06	.04	.02	202.	1.01	18.40	224	.02	.02	.00	502.
1.01	6.45	81	.06	.04	.02	222.	1.01	18.45	225	.02	.02	.00	403.
1.01	6.50	82	.04	.04	.02	239.	1.01	18.50	226	.02	.02	.00	331.
1.01	6.55	83	.06	.04	.02	254.	1.01	18.55	227	.02	.02	.00	278.
1.01	7.00	84	.06	.04	.02	268.	1.01	19.00	228	.02	.02	.00	239.
1.01	7.05	85	.06	.04	.02	280.	1.01	19.05	229	.02	.02	.00	210.
1.01	7.10	86	.06	.05	.02	290.	1.01	19.10	230	.02	.02	.00	189.
1.01	7.15	87	.06	.05	.02	300.	1.01	19.15	231	.02	.02	.00	174.
1.01	7.20	88	.06	.05	.02	309.	1.01	19.20	232	.02	.02	.00	163.
1.01	7.25	89	.06	.05	.02	317.	1.01	19.25	233	.02	.02	.00	155.
1.01	7.30	90	.06	.05	.02	324.	1.01	19.30	234	.02	.02	.00	149.
1.01	7.35	91	.06	.05	.02	331.	1.01	19.35	235	.02	.02	.00	145.
1.01	7.40	92	.06	.05	.01	337.	1.01	19.40	236	.02	.02	.00	142.
1.01	7.45	93	.06	.05	.01	343.	1.01	19.45	237	.02	.02	.00	139.
1.01	7.50	94	.06	.05	.01	349.	1.01	19.50	238	.02	.02	.00	138.
1.01	7.55	95	.06	.05	.01	354.	1.01	19.55	239	.02	.02	.00	136.
1.01	8.00	96	.06	.05	.01	359.	1.01	20.00	240	.02	.02	.00	135.
1.01	8.05	97	.06	.05	.01	363.	1.01	20.05	241	.02	.02	.00	135.
1.01	8.10	98	.06	.05	.01	368.	1.01	20.10	242	.02	.02	.00	135.
1.01	8.15	99	.06	.05	.01	372.	1.01	20.15	243	.02	.02	.00	135.
1.01	8.20	100	.06	.05	.01	375.	1.01	20.20	244	.02	.02	.00	135.
1.01	8.25	101	.06	.05	.01	379.	1.01	20.25	245	.02	.02	.00	135.
1.01	8.30	102	.06	.05	.01	382.	1.01	20.30	246	.02	.02	.00	135.
1.01	8.35	103	.06	.05	.01	385.	1.01	20.35	247	.02	.02	.00	135.
1.01	8.40	104	.06	.05	.01	389.	1.01	20.40	248	.02	.02	.00	135.
1.01	8.45	105	.06	.05	.01	391.	1.01	20.45	249	.02	.02	.00	135.
1.01	8.50	106	.06	.05	.01	394.	1.01	20.50	250	.02	.02	.00	135.
1.01	8.55	107	.06	.06	.01	397.	1.01	20.55	251	.02	.02	.00	135.
1.01	9.00	108	.06	.06	.01	399.	1.01	21.00	252	.02	.02	.00	135.
1.01	9.05	109	.06	.06	.01	402.	1.01	21.05	253	.02	.02	.00	135.
1.01	9.10	110	.06	.06	.01	404.	1.01	21.10	254	.02	.02	.00	135.
1.01	9.15	111	.06	.06	.01	406.	1.01	21.15	255	.02	.02	.00	135.
1.01	9.20	112	.06	.06	.01	408.	1.01	21.20	256	.02	.02	.00	135.
1.01	9.25	113	.06	.06	.01	410.	1.01	21.25	257	.02	.02	.00	135.
1.01	9.30	114	.06	.06	.01	412.	1.01	21.30	258	.02	.02	.00	135.
1.01	9.35	115	.06	.06	.01	414.	1.01	21.35	259	.02	.02	.00	135.
1.01	9.40	116	.06	.06	.01	416.	1.01	21.40	260	.02	.02	.00	135.
1.01	9.45	117	.06	.06	.01	417.	1.01	21.45	261	.02	.02	.00	135.
1.01	9.50	118	.06	.06	.01	419.	1.01	21.50	262	.02	.02	.00	135.
1.01	9.55	119	.06	.06	.01	420.	1.01	21.55	263	.02	.02	.00	135.
1.01	10.00	120	.06	.06	.01	422.	1.01	22.00	264	.02	.02	.00	135.
1.01	10.05	121	.06	.06	.01	423.	1.01	22.05	265	.02	.02	.00	135.

1.01	10.10	122	.06	.06	.01	425.	1.01	22.10	266	.02	.02	.00	135.
1.01	10.15	123	.06	.06	.01	426.	1.01	22.15	267	.02	.02	.00	135.
1.01	10.20	124	.06	.06	.01	427.	1.01	22.20	268	.02	.02	.00	135.
1.01	10.25	125	.06	.06	.01	428.	1.01	22.25	269	.02	.02	.00	135.
1.01	10.30	126	.06	.06	.01	430.	1.01	22.30	270	.02	.02	.00	135.
1.01	10.35	127	.06	.06	.01	431.	1.01	22.35	271	.02	.02	.00	135.
1.01	10.40	128	.06	.06	.01	432.	1.01	22.40	272	.02	.02	.00	135.
1.01	10.45	129	.06	.06	.01	433.	1.01	22.45	273	.02	.02	.00	135.
1.01	10.50	130	.06	.06	.00	434.	1.01	22.50	274	.02	.02	.00	135.
1.01	10.55	131	.06	.06	.00	435.	1.01	22.55	275	.02	.02	.00	135.
1.01	11.00	132	.06	.06	.00	436.	1.01	23.00	276	.02	.02	.00	135.
1.01	11.05	133	.06	.06	.00	437.	1.01	23.05	277	.02	.02	.00	135.
1.01	11.10	134	.06	.06	.00	437.	1.01	23.10	278	.02	.02	.00	135.
1.01	11.15	135	.06	.06	.00	438.	1.01	23.15	279	.02	.02	.00	135.
1.01	11.20	136	.06	.06	.00	439.	1.01	23.20	280	.02	.02	.00	135.
1.01	11.25	137	.06	.06	.00	440.	1.01	23.25	281	.02	.02	.00	135.
1.01	11.30	138	.06	.06	.00	441.	1.01	23.30	282	.02	.02	.00	135.
1.01	11.35	139	.06	.06	.00	441.	1.01	23.35	283	.02	.02	.00	135.
1.01	11.40	140	.06	.06	.00	442.	1.01	23.40	284	.02	.02	.00	135.
1.01	11.45	141	.06	.06	.00	443.	1.01	23.45	285	.02	.02	.00	135.
1.01	11.50	142	.06	.06	.00	444.	1.01	23.50	286	.02	.02	.00	135.
1.01	11.55	143	.06	.06	.00	444.	1.01	23.55	287	.02	.02	.00	135.
1.01	12.00	144	.06	.06	.00	445.	1.02	0.00	288	.02	.02	.00	135.
SUM										31.46	29.59	1.87	219763.
										(799.)	(752.)	(48.)	(6223.00)

CFS
 CFS
 INCHES
 IN
 AC-FT
 THOUS CU M

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 1

CFS
 CFS
 INCHES
 IN
 AC-FT
 THOUS CU M

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 2

CFS
 CFS
 INCHES
 IN
 AC-FT
 THOUS CU M

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 3

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL	VOLUME
CFS	1134.	372.	114.	114.		32954.
CMS	32.	11.	3.	3.		933.
INCHES		3.59	4.42	4.42		4.42
MM		91.19	112.30	112.30		112.30
AC-FT		184.	227.	227.		227.
THOUS CU M		227.	280.	280.		280.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 4

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL	VOLUME
CFS	1512.	496.	153.	153.		43938.
CMS	43.	14.	4.	4.		1244.
INCHES		4.79	5.89	5.89		5.89
MM		121.58	149.73	149.73		149.73
AC-FT		246.	303.	303.		303.
THOUS CU M		303.	373.	373.		373.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 5

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL	VOLUME
CFS	2647.	867.	267.	267.		76892.
CMS	75.	25.	8.	8.		2177.
INCHES		8.38	10.32	10.32		10.32
MM		212.77	262.03	262.03		262.03
AC-FT		430.	530.	530.		530.
THOUS CU M		530.	653.	653.		653.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 6 1/2 PMF

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL	VOLUME
CFS	3781.	1239.	381.	381.		109846.
CMS	107.	35.	11.	11.		3110.
INCHES		11.97	14.74	14.74		14.74
MM		303.95	374.33	374.33		374.33
AC-FT		614.	757.	757.		757.
THOUS CU M		758.	933.	933.		933.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 7

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL	VOLUME
CFS	5471.	1858.	572.	572.		164769.
CMS	161.	53.	16.	16.		4666.
INCHES		17.95	22.11	22.11		22.11
MM		455.93	561.49	561.49		561.49
AC-FT		921.	1135.	1135.		1135.
THOUS CU M		1137.	1400.	1400.		1400.

HYDROGRAPH AT STA000001 FOR PLAN 1, RTIO 8 PMF

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL	VOLUME
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PLATE D-12

STATION 000002, PLAN 1, RATIO $\frac{1}{2}$ P.M.F.
END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW									
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	2.	2.	3.	3.	3.	3.	3.	4.	4.
4.	5.	5.	6.	6.	7.	7.	7.	7.	8.
8.	9.	9.	10.	10.	10.	11.	11.	11.	12.
12.	13.	13.	14.	16.	16.	20.	25.	31.	38.
45.	54.	63.	71.	77.	80.	82.	85.	88.	88.
90.	92.	94.	96.	98.	100.	102.	104.	107.	117.
126.	133.	140.	146.	152.	157.	161.	165.	169.	173.
176.	179.	181.	184.	186.	188.	190.	192.	194.	196.
197.	199.	200.	201.	203.	204.	205.	206.	207.	208.
209.	210.	210.	211.	212.	213.	213.	215.	215.	215.
216.	216.	217.	217.	218.	220.	229.	247.	273.	307.
348.	403.	453.	498.	568.	626.	664.	690.	712.	734.
757.	781.	804.	824.	856.	887.	897.	893.	891.	891.
904.	923.	948.	977.	1007.	1035.	1058.	1077.	1092.	1103.
1110.	1112.	1110.	1111.	1130.	1195.	1362.	1780.	2456.	3104.
3557.	3717.	3604.	3291.	2879.	2479.	2145.	1877.	1668.	1511.
1432.	1354.	1288.	1235.	1193.	1158.	1125.	1091.	1054.	1016.
979.	946.	920.	900.	884.	873.	862.	844.	809.	751.
670.	576.	496.	449.	399.	349.	282.	252.	224.	224.
210.	197.	185.	173.	163.	152.	143.	134.	127.	120.
113.	107.	105.	104.	103.	102.	101.	101.	100.	99.
98.	97.	97.	96.	95.	95.	94.	93.	92.	92.
91.	90.	90.	89.	89.	88.	88.	87.	86.	86.
85.	85.	84.	83.	83.	82.	82.	81.	81.	80.
80.	79.	79.	78.	78.	77.	77.	77.	77.	77.
STORAGE									
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
32.	32.	32.	33.	33.	34.	34.	35.	35.	36.
36.	37.	37.	38.	38.	39.	40.	40.	41.	41.
42.	42.	42.	43.	43.	44.	44.	44.	44.	44.
44.	44.	44.	45.	45.	45.	45.	45.	46.	46.
46.	46.	46.	46.	46.	46.	46.	46.	46.	46.
47.	47.	47.	47.	47.	47.	47.	47.	47.	47.
47.	47.	47.	47.	47.	47.	48.	49.	50.	50.
52.	53.	55.	56.	57.	58.	58.	59.	59.	59.
59.	59.	60.	60.	60.	60.	60.	60.	61.	61.
61.	61.	61.	61.	62.	62.	62.	63.	63.	63.
63.	63.	63.	63.	63.	64.	65.	68.	72.	75.
77.	78.	78.	76.	74.	72.	70.	69.	68.	67.
66.	65.	65.	64.	64.	63.	63.	63.	62.	62.
58.	57.	56.	55.	53.	52.	51.	49.	48.	47.
47.	46.	45.	44.	44.	43.	43.	42.	42.	41.

41.	40.	40.	40.	40.	40.	39.	39.	39.
38.	38.	38.	38.	38.	38.	37.	37.	37.
37.	36.	36.	36.	36.	36.	36.	35.	35.
35.	35.	35.	35.	35.	35.	34.	34.	34.
34.	34.	34.	34.	34.	34.	34.	34.	34.
STAGE								
890.0	890.0	890.0	890.0	890.0	890.0	890.0	890.0	890.0
890.0	890.0	890.0	890.0	890.0	890.0	890.0	890.0	890.0
890.0	890.0	890.0	890.0	890.0	890.0	890.0	890.0	890.0
890.0	890.0	890.0	890.0	890.0	890.0	890.0	890.0	890.0
890.1	890.2	890.2	890.2	890.1	890.1	890.1	890.1	890.1
890.3	890.3	890.3	890.3	890.3	890.3	890.3	890.3	890.3
890.4	890.4	890.4	890.4	890.4	890.4	890.4	890.4	890.4
890.4	890.4	890.4	890.4	890.4	890.4	890.4	890.4	890.4
891.0	891.2	891.3	891.4	891.5	891.6	891.7	891.8	891.9
892.2	892.3	892.4	892.5	892.6	892.7	892.8	892.9	893.0
893.2	893.2	893.3	893.4	893.4	893.4	893.5	893.5	893.6
893.6	893.6	893.7	893.7	893.7	893.7	893.7	893.8	893.8
893.8	893.8	893.8	893.8	893.8	893.9	893.9	893.9	893.9
893.9	893.9	893.9	893.9	893.9	893.9	893.9	893.9	894.0
894.0	894.0	894.0	894.0	894.0	894.0	894.0	894.0	894.0
894.5	894.7	894.8	895.0	895.1	895.1	895.2	895.2	895.2
895.3	895.3	895.3	895.3	895.4	895.4	895.4	895.4	895.4
895.4	895.4	895.5	895.5	895.5	895.6	895.6	895.6	895.6
895.6	895.6	895.6	895.6	895.7	895.7	895.7	895.7	895.7
896.9	896.9	896.9	896.8	896.6	896.4	896.3	896.2	896.0
895.9	895.9	895.8	895.8	895.7	895.7	895.7	895.6	895.5
895.5	895.5	895.4	895.4	895.4	895.4	895.4	895.3	895.3
895.2	895.1	895.0	894.8	894.7	894.5	894.4	894.1	894.0
893.9	893.8	893.7	893.6	893.5	893.4	893.3	893.2	893.1
893.1	893.0	893.0	892.9	892.9	892.8	892.8	892.7	892.7
892.6	892.6	892.6	892.5	892.5	892.5	892.4	892.3	892.3
892.3	892.2	892.2	892.2	892.1	892.1	892.1	892.0	892.0
892.0	891.9	891.9	891.9	891.9	891.8	891.8	891.8	891.7
891.7	891.7	891.7	891.7	891.7	891.6	891.6	891.6	891.6

PEAK OUTFLOW IS 3717. AT TIME 16.00 HOURS

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
3717.	1230.	378.	378.	109003.
105.	35.	11.	11.	3087.
CFS	11.88	14.62	14.62	14.62
CMS	301.67	371.45	371.45	371.45
INCHES	610.	751.	751.	751.
MM	752.	926.	926.	926.
AC-FT				
THOUS CU H				

PLATE D-15

PLATE D-16

15.05181.
 15.10182.
 15.15183.
 15.20184.
 15.25185.
 15.30186.
 15.35187.
 15.40188.
 15.45189.
 15.50190.
 15.55191.
 16.00192.
 16.05193.
 16.10194.
 16.15195.
 16.20196.
 16.25197.
 16.30198.
 16.35199.
 16.40200.
 16.45201.
 16.50202.
 16.55203.
 17.00204.
 17.05205.
 17.10206.
 17.15207.
 17.20208.
 17.25209.
 17.30210.
 17.35211.
 17.40212.
 17.45213.
 17.50214.
 17.55215.
 18.00216.
 18.05217.
 18.10218.
 18.15219.
 18.20220.
 18.25221.
 18.30222.
 18.35223.
 18.40224.
 18.45225.
 18.50226.
 18.55227.
 19.00228.
 19.05229.
 19.10230.
 19.15231.
 19.20232.
 19.25233.
 19.30234.
 19.35235.
 19.40236.
 19.45237.
 19.50238.
 19.55239.
 20.00240.
 20.05241.
 20.10242.

•OWN•

STATION 000002, PLAN 1, RATIO 2 **PMF**

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW									
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3.	3.	4.	4.	5.	5.	1.	1.	7.	8.
9.	9.	10.	11.	12.	12.	13.	13.	14.	15.
17.	17.	19.	21.	22.	23.	23.	24.	25.	27.
27.	27.	29.	31.	33.	38.	45.	56.	69.	76.
81.	87.	91.	96.	100.	104.	124.	145.	164.	181.
196.	210.	225.	247.	265.	281.	295.	307.	317.	327.
335.	345.	354.	361.	368.	373.	378.	383.	387.	390.
393.	396.	399.	402.	404.	407.	409.	411.	413.	414.
416.	419.	421.	422.	424.	425.	426.	428.	429.	438.
430.	431.	432.	433.	434.	435.	436.	437.	438.	439.
440.	441.	442.	442.	444.	452.	473.	516.	645.	781.
916.	1040.	1144.	1228.	1292.	1341.	1379.	1409.	1444.	1483.
1534.	1599.	1648.	1686.	1716.	1738.	1755.	1767.	1780.	179.
1828.	1877.	1939.	2004.	2066.	2118.	2159.	2188.	2210.	222.
2234.	2231.	2220.	2223.	2284.	2475.	2936.	3789.	5258.	6567.
7359.	7512.	7139.	6406.	5535.	4743.	4111.	3667.	3306.	3003.
2773.	2603.	2479.	2388.	2320.	2261.	2200.	2129.	2051.	1972.
1899.	1838.	1792.	1761.	1739.	1723.	1703.	1659.	1567.	1446.
1296.	1116.	932.	762.	617.	506.	462.	416.	372.	333.
308.	284.	263.	243.	226.	215.	208.	201.	194.	188.
183.	178.	173.	169.	165.	162.	159.	157.	154.	152.
150.	148.	147.	146.	144.	143.	142.	141.	140.	140.
139.	139.	138.	138.	138.	137.	137.	137.	137.	136.
136.	136.	136.	136.	136.	136.	136.	136.	136.	135.
135.	135.	135.	135.	135.	135.	135.	135.	135.	135.

STORAGE

28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
29.	29.	29.	29.	29.	29.	29.	29.	29.	29.
30.	30.	30.	30.	30.	30.	30.	30.	30.	30.
30.	30.	30.	30.	30.	30.	30.	30.	30.	30.
31.	31.	31.	31.	31.	31.	31.	31.	31.	31.
36.	37.	37.	38.	39.	40.	41.	43.	44.	45.
46.	47.	47.	48.	49.	49.	50.	50.	51.	51.
51.	52.	52.	52.	52.	52.	53.	53.	53.	53.
53.	53.	53.	53.	53.	53.	53.	53.	54.	54.
54.	54.	54.	54.	54.	54.	54.	54.	54.	54.
54.	54.	54.	54.	54.	54.	54.	54.	54.	54.
61.	62.	63.	64.	65.	65.	66.	66.	67.	67.
67.	67.	68.	68.	68.	68.	68.	68.	68.	68.
69.	69.	69.	70.	70.	70.	70.	71.	71.	71.
71.	71.	71.	71.	71.	72.	74.	79.	84.	88.
90.	91.	90.	87.	85.	82.	80.	78.	76.	75.
74.	73.	72.	72.	71.	71.	71.	70.	69.	69.
69.	69.	68.	68.	68.	68.	68.	68.	67.	66.
65.	63.	61.	59.	57.	56.	55.	54.	52.	51.
50.	50.	49.	48.	48.	47.	46.	46.	46.	45.

PLATE D-20

9. 55119.
10. 00120.
10. 05121.
10. 10122.
10. 15123.
10. 20124.
10. 25125.
10. 30126.
10. 35127.
10. 40128.
10. 45129.
10. 50130.
10. 55131.
11. 00132.
11. 05133.
11. 10134.
11. 15135.
11. 20136.
11. 25137.
11. 30138.
11. 35139.
11. 40140.
11. 45141.
11. 50142.
11. 55143.
12. 00144.
12. 05145.
12. 10146.
12. 15147.
12. 20148.
12. 25149.
12. 30150.
12. 35151.
12. 40152.
12. 45153.
12. 50154.
12. 55155.
13. 00156.
13. 05157.
13. 10158.
13. 15159.
13. 20160.
13. 25161.
13. 30162.
13. 35163.
13. 40164.
13. 45165.
13. 50166.
13. 55167.
14. 00168.
14. 05169.
14. 10170.
14. 15171.
14. 20172.
14. 25173.
14. 30174.
14. 35175.
14. 40176.
14. 45177.
14. 50178.
14. 55179.
15. 00180.

PLATE D-27

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS							
				RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8
				.05	.10	.15	.20	.35	.50	.75	1.00
HYDROGRAPH AT	000001	.96 (2.49)	1	373. (10.71)	753. (21.41)	1134. (32.12)	1512. (42.82)	2647. (74.94)	3781. (107.06)	5671. (160.59)	7562. (214.12)
	ROUTED TO	.96 (2.49)	1	206. (5.84)	625. (17.68)	1037. (29.38)	1405. (39.80)	2596. (73.52)	3717. (105.27)	5632. (159.47)	7512. (212.72)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	ELEVATION STORAGE OUTFLOW	INITIAL VALUE 890.00 28. 0.	SPILLWAY CREST 890.00 28. 0.	TOP OF DAM 894.70 53. 405.					
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS		
.05	893.87	0.00	46.	206.	0.00	16.33	0.00		
.10	895.13	.43	58.	625.	.75	16.17	0.00		
.15	895.56	.86	62.	1037.	1.50	16.08	0.00		
.20	895.91	1.21	66.	1405.	2.92	16.08	0.00		
.35	896.48	1.78	73.	2596.	5.50	16.00	0.00		
.50	896.92	2.22	78.	3717.	6.00	16.00	0.00		
.75	897.42	2.72	85.	5632.	6.50	16.00	0.00		
1.00	897.94	3.14	91.	7512.	9.42	16.00	0.00		

END

DATE
FILMED

12-8

DTIC